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(71)(72) Applicant and Inventor: CHARLES, Jeffrey, R. [US/US]; 2454 E. Washington Boulevard, Pasadena, CA 91104 (US).

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(57) Abstract

The present invention relates to an omnidirectional wide angle optical system, which is associated with a camera, projector, medical instrument, surveillance system, flight control system, or similar article. The optical system consists of a strongly curved external refracting surface, a strongly curved internal primary reflector surface, a secondary reflector surface (in most embodiments), central wide angle refracting optics (in some embodiments), a modular or integral imaging and correcting lens system having aperture adjustement means, and mounting components. Optical surfaces associated with the formation of an omnidirectional virtual image are typically integrated into a single solid catadioptric optic in some embodiments, but the central wide angle refracting optics are separate optical elements in other embodiments.

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# SOLID CATADIOPTRIC OMNIDIRECTIONAL OPTICAL SYSTEM HAVING CENTRAL COVERAGE MEANS WHICH IS ASSOCIATED WITH A CAMERA, PROJECTOR, MEDICAL INSTRUMENT, OR SIMILAR ARTICLE

To the Commissioner of Patents and Trademarks:

Your petitioner, Jeffrey R. Charles, a citizen of the United States and a resident of Pasadena, State of California, whose post-office address is 2454 East Washington Blvd., prays that letters patent may be granted him for the improvement in an Solid Catadioptric Omnidirectional Optical System Having Central Coverage Means Which Is Associated With A Camera, Medical Instrument, Projector, or Similar Article, set forth in the following specification.

This application claims the benefit of U.S. provisional application serial number 60/043,701, filed April 16, 1997. Further, this application claims the benefit of U.S. provisional application serial number 60/055,876, filed August 15, 1997 for claims specifically referenced thereto. Still further, this application claims the benefit of all specified prior art which was originated by the applicant and published less than one year prior to the present application. Yet further, this application claims the benefit of all prior art which was originated by the applicant and is verifiably documented by other means, including any applicable material which may be in his prior U.S. design patent D312,263. All claims not specifically supported in provisional application serial number 60/043,701 are so noted herein. This application primarily addresses drawing sheets originally numbered 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 in U.S. provisional application serial number 60/043,701, Filed April 16, 1997.

Additionally, this application references all appropriate elements of U.S. provisional application serial number 60/043,701, filed April 16, 1997, including forms such as the verified statement claiming small entity status, information disclosures, the filing date; copies of prior art references, descriptions, drawings, remarks, and all other related elements for the purpose of covering any errors or omissions which may exist herein until such a time as he is requested to remove said references or material by an examiner or other duly authorized patent personnel for purposes such as formality, or until or unless he otherwise requests its removal. Further, if it is permitted, the applicant specifies that the entirety of the accompanying document entitled "Cover Letter, Introductory Remarks, Details Relating to Prior Art Information Disclosure" is considered part of the specification of this application for the purpose of covering any errors or omissions which may exist herein until such a time as he is requested to remove it by an examiner or other duly authorized personnel for the purposes such as formality, until or unless he otherwise requests its removal, or files a continuing application for material therein which may not end up in the patent as issued. Material in the accompanying document is intended to assist the examiner during examination of this application and includes substantial material which may otherwise be in a response to an examiner's action, where said action may be based on said examiner not being privy to information therein; however, it is not necessarily intended as permanent text for the patent, so it is provided as a separate, separately numbered document to facilitate the removal of some or all elements therein from the present specification in a way which is easy to communicate. The specification herein includes page numbers at the top of each page; however, said page numbers are not intended to be part of said specification text, so they are printed outside the specified one inch top margin. Some or all of this paragraph is not intended to be part of the final specification, except allowable elements herein which reference other material. Therefore, elements of this paragraph that are informal or otherwise not required in this specification shall presumably be removed prior to the issue of any resulting patent.

## BACKGROUND OF THE INVENTION

The present invention relates to a wide angle omnidirectional optical system providing means for the simultaneous and seamless imaging of the entire great circle perpendicular to its optical axis, also encompassing a wide angular area on either side of the plane of said great circle. More particularly, the invention relates to an imaging system providing means for simultaneous and seamless imaging of the entire sphere around itself with the exception of a narrow conical area extending from the rear perimeter of said optical system to an axial point disposed a finite distance behind said optical system. The optical system includes reflecting and refracting optical surfaces, said optical surfaces providing means for the geometric conversion of three dimensional space surrounding the invention into a two dimensional annular image or vice versa; said optical system being associated with or incorporated into a film camera, electronic camera, electronic sensor, projector, medical instrument, surveillance system, robotic system, flight control system, simulator, or similar article. Images produced or projected by the invention are applicable to many fields, including still, time lapse, or full motion indoor and outdoor panoramic photography with various format cameras, sensors or other devices utilizing a focal surface; omniramic and omnidirectional recording of subjects for virtual reality applications with a film camera, electronic camera, or similar article; omniramic or omnidirectional projection of recorded, artificially generated, or hybrid images; videography; live broadcast including that via radio carrier waves, closed circuit systems, or the Internet; underwater imaging including imaging of shipwrecks at great depths; surveillance; minimally invasive omnidirectional observation and imaging of difficult to access subjects, as applicable to covert surveillance, dry or immersion bore scopes, endoscopy, laparascopic medical procedures, colonoscopy, intravascular procedures; conventional and immersion wide angle microscopy; the enabling and enhancement of conventional or micro assembly and inspection techniques; omnidirectional expansion or

reception of lasers and other light sources for applications including illumination, optical communication, or optical motion sensing; robotic vision systems; vision and subject recognition for autonomous and other flight control or simulation systems, including virtual reality systems and missile systems; and for viewing, observing, measuring, imaging, recording, broadcasting, projecting, or simulating defined or diffuse subjects of large angular subtense, such as weather related events or the boundary of the lunar umbra as projected on the earth's atmosphere during a total solar eclipse. The optical system may be used in any orientation; however, it is typically used in a vertical orientation for panoramic applications. The omnidirectional imaging system typically consists of a curved external refracting surface; a strongly curved primary reflector surface, said primary reflecting surface having sufficient curvature to image a field of view greater than 180 degrees, thereby providing means to image a great circle surrounding it; a secondary reflector surface (in most embodiments); an imaging and correcting lens system; and mechanical mounting components. All optical surfaces are integrated into a single solid catadioptric optic for some applications, but the imaging and correcting lens system can be separate optical elements which are attached to said solid optic for other applications. Some embodiments utilize central wide angle refracting optics which are disposed in front of a hole in the secondary reflector coating, whereby said wide angle refracting optics provide means for imaging the area directly in front of the overall optical system, said imaged area being redundant in some embodiments and merged with the annular image produced by other optical surfaces in different embodiments. Where a focal surface is associated with the invention, said focal surface is in optical communication with the entire sphere around the optical system by means of refraction through the outer refracting surface, reflection from the primary reflector, reflection from the secondary reflector (in embodiments having one), and refraction by imaging and correcting optics.

## DESCRIPTION OF THE PRIOR ART:

Assembly of a plurality of discrete images to form a fixed or moving panoramic image is common in the prior art. A less common image assembly method relates to coverage the entire sphere around a camera by means of assembling opposing images taken with a fisheye lens having a field of view greater than or equal to 180 degrees. One such type of prior art relates to the simultaneous use of two hyperhemispherical fisheye lenses to take still images, as embodied in Dan Slater's Spherecam. Another relates to the alternate use of a single hemispherical fisheye lens to alternately capture images in opposing directions, said fisheye lens being used in combination with an indexing bracket having means to index the 180 degree zone of the typically distorted entrance pupil of said fisheye lens in the same position when recording each of the opposing still images, as embodied in the IPIX system and related to U.S. patents 5,384,588 and 5,631,778. Motion picture systems include the multiple projector Circle Vision 360 theater at Disneyland and other systems having various degrees of coverage such as planetariums equipped with single projector Omnimax projectors.

The use of a single refractive optical system in hyperhemispherical and panoramic imaging is common in the prior art. Systems utilizing entirely refractive means include rotating panoramic cameras, fisheye lenses, and J.M. Slater's whole sky lens, as shown on page 582 of the October 1932 issue of American Photographer.

Reflectors are widely used in hyperhemispherical wide angle panoramic imaging and projection. Systems of this type are shown in U.S. Patent Nos. 5,631,778 (Panoramic fish-eye imaging system), 5,115,266 (Optical system for recording or projecting a panoramic image), 4,395,093 (Lens system for panoramic imagery), 4,012,126 (Optical system for 360 degree image transfer), 3,846,809 (Reflectors and mounts for panoramic projection), 3,822,936 (Optical system for panoramic projection), and D312,263 (Wide angle reflector attachment for

a camera or similar article), and as embodied in disclosures of the Omnicamera at the www.cs.columbia.edu web site and the Cyclovision ParaCamera (introduced in 1998); the Be Here Portal S1 panoramic lens prototype at the www.behere.com web site; and the Versacorp Omnirama T11 axial strut omniramic reflector at the www.versacorp.com web site.

Optical reflector configurations include a simple reflector disposed directly in front of a camera lens, as embodied in the Spiratone Birds Eye Attachment (shown in the Spiratone 1976 Bicentennial Sale catalog, page 28), to a Cassegrain system having integral imaging optics as shown in U.S. Patent Nos. 4,012,126 (Optical system for 360 degree image transfer) and Figures 6 through 12 of U.S. Patent No. D312,263 (the applicant's patent for a Wide angle reflector attachment for a camera or similar article).

Support means for a camera or reflective optical element include a tripod or multiple vane spider; support rods on opposing sides of an optical system as in an embodiment of the Omnicamera at the www.cs.columbia.edu web site; a transparent cylinder,as embodied in the Spiratone Birds Eye Attachment; a transparent hollow semi-sphere of the type shown in U.S. Patent Nos. 4,395,093 (Lens system for panoramic imagery), 4,012,126 (Optical system for 360 degree image transfer), or an embodiment of the Omnicamera at the www.cs.columbia.edu web site; an axial strut of the type shown in U.S. Patent Nos. 5,115,266 (Optical system for recording or projecting a panoramic image), 3,846,809 (Reflectors and mounts for panoramic projection), and D312,263 (Wide angle reflector attachment for a camera or similar article), or pages 74 to 80 of the 1988 Riverside Telescope Makers Conference proceedings; and a solid optical substrate of the type used in the Peri-Apollar lens, and the Versacorp OmniLens at the www.versacorp.com web site. (Remarks: The Versacorp OmniLens is the present invention, and Versacorp is the applicant's business. OmniLens data was not uploaded to the www.versacorp.com web site until after the filing of provisional application serial No. 60/043,701, and said data does not show or describe the reflective nature of the invention.)

Reflective surfaces consist of one or more external reflectors, as shown in U.S. Patent Nos. 5,115,266 (Optical system for recording or projecting a panoramic image), 3,846,809 (Reflectors and mounts for panoramic projection), and D312,263 (Wide angle reflector attachment for a camera or similar article); an internal optical surface having a reflective coating as shown in the JPL Radial Profilometry paper by Gregus and Matthys; and an internal surface which utilizes total internal reflection, as embodied in the Peri-Apollar lens.

Reflector substrates include spun, machined, polished and conventionally plated metal surfaces as embodied in the applicant's larger reflector invention on page 186 of the August 1986 issue of Sky and Telescope, page 68 of the April 1987 issue of Astronomy, and as shown and described on pages 74 through 80 of the proceedings of the 1988 Riverside Telescope Makers Conference; electrolytically replicated metal surfaces, including those having an outer coating of rhodium, as embodied in Melles Griot concave light multipliers on page 12-17 of the Optics Guide 5 catalog; glass having a reflective coating, as embodied in the Spiratone Birds Eye attachment; transparent refractive material having an exterior reflective coating, as shown in the applicant's U.S. Patent No. D312,263 (Wide angle reflector attachment for a camera or similar article. Remarks: This feature may only be obvious to the applicant.); and plastic having a reflective coating, as embodied in the applicant's smaller reflector system on page 186 of the August 1986 issue of Sky and Telescope.

Internal reflectors within minimally unobstructed transparent substrates are less common, but are embodied in the Peri-Apollar and the applicant's unpublished prior art.

Some of the prior art consists of or incorporates refracting optics to eliminate field curvature, as shown U.S. Patent No. 4,484,801 (Panoramic lens with elements to correct Petzval curvature), and field flattener systems for astronomical telescopes. Used alone, reflector systems can produce aberrations, with the most severe aberrations typically being off-axis.

Some prior art may utilize refracting optics to reduce aberrations, as is presumably shown in U.S. Patent No. 4,012,126 (Optical system for 360 degree image transfer) and as claimed for the Be Here Portal S1 by Be Here personnel in a bulletin board posting. (Remarks: This Email posting was subsequent to the filing date of the applicant's provisional applications, serial Nos. 60/043,701 and 60/055,876.) Other prior art utilizes a second reflective surface to control aberrations, as embodied in Cassegrain telescopes.

Use of a second reflector to control aberrations is applicable to the field of the present invention, and many of these principles can be most elegantly addressed through examination of prior art in the more mature field of Cassegrain telescopes and telephoto catadioptric camera lenses: In these systems, the relative figures of the primary and secondary mirrors can be manipulated in order to reduce imaged on-axis aberrations to a size smaller than the Airy disk. In addition, the figures of the primary and secondary mirrors can be manipulated to affect off-axis aberrations in a way which reduces the severity of aberrations or results in an aberration which is relatively practical to correct by means of relatively small auxiliary refracting optics which are located relatively near the focal plane. Cassegrain telescope systems include the Ritchey-Chrétien, a telescope having a concave hyperboloidal primary mirror and a convex hyperboloidal secondary mirror. This combination results in off-axis astigmatism, an aberration relatively difficult to correct with refracting optics if they are located in close proximity to the focal plane. Another Cassegrain system is the Classical Cassegrain, a telescope having a concave paraboloidal primary mirror and a convex hyperboloidal secondary mirror. Coma is the predominant aberration with this system, and coma is relatively easy to correct or reduce with refracting optics, even if they are located relatively near the focal plane. Accordingly, refractive coma correctors are commonly available for commercial Cassegrain telescopes. Simpler published coma corrector designs include those by Brixner, Jones, and Jones-Bird.

These simpler corrector systems are designed for Newtonian telescopes and they correct coma at the expense of introducing other aberrations; however, these are advantageous when their use will reduce the overall size of the combined imaged aberrations to an acceptable level. A more effective corrector for Classical Cassegrain and Schmidt-Cassegrain telescopes is a four element system offered by Celestron, and more recently, by Meade Instruments. This optical system has substantial positive optical power which results in a smaller (faster) numerical focal ratio at the focal plane than that of the telescope alone. More sophisticated corrector lenses are utilized in compact Catadioptric telephoto camera lenses. These include the Nikon 500 mm telephoto mirror lens and the Vivitar 800 mm Solid Catadioptric telephoto lens for a 35 mm camera. In telephoto lenses, corrective lenses are occasionally used in combination with reflective optics in which imaging aberrations roughly equal and opposite of residual aberrations of said corrective lenses have been deliberately introduced.

In the case of a convex wide angle reflector, a virtual image typically exists on an imaginary curved surface typically being disposed behind the apex of said convex reflector. When a real image is produced by means of imaging the virtual image with a conventional lens system, aberrations present in said virtual image are typically repeated to the real image. In addition, the curvature of the virtual image results in curvature of the surface of best focus for the real image. Therefore, a wide angle reflector system must incorporate or otherwise utilize means for correcting field curvature and reducing or correcting aberrations in the virtual image if the real image is to be of high overall resolution and still facilitate a flat focal surface. Imaging lens systems having means to correct field curvature and at least some aberrations exist in the prior art. An imaging lens system of this type is shown in U.S. patent Nos. 4,484,801 (Panoramic lens with elements to correct Petzval curvature), 4,395,093 (Lens system for panoramic imagery), 4,012,126 (Optical system for 360 degree image transfer).

Corrective optics not previously associated with wide angle imaging include a curved field lens system of the type used to sharply image the curved surface of a CRT, as embodied in older oscilloscope cameras. Use of such optics and optics based on similar principles is applicable to some embodiments of the present invention, where such use does not infringe on other claims.

Primary wide angle reflector figures include concave, as shown in U.S. Patent No. 5,631,778; convex spherical, as shown in the hubcap used in the applicant's larger reflector system on page 186 of the August 1986 issue of Sky and Telescope; and aspheric, as shown in the applicant's U.S. Patent D312,263 (Wide angle reflector attachment for a camera or similar article).

Secondary reflector figures include flat, as shown in U.S. Patents 5,115,266 (Optical system for recording or projecting a panoramic image), and D312,263 (Wide angle reflector attachment for a camera or similar article); concave, as shown in U.S. Patent 4,012,126 (Optical system for 360 degree image transfer); and convex, as in the applicant's pending U.S. patent application of 7 March, 1998.

All references cited in the applicant's patent D312,263 can be considered "Prior Art Cited By Applicant" in the present application.

In the field of the present invention, it is important to distinguish between two definitions which are often applied to the concept of an "omnidirectional" field of view or a 360 degree angle (or field) of view:

The most accurate definition relates to the actual angle of view of an optical system, where the specified angle of view is determined by the true angular coverage of the system relative to its optical axis; meaning that if an optical system is truly has 360 degree omnidirectional coverage, it must cover the entire sphere around itself. According to this definition, the present invention is capable of imaging the entire sphere in a contiguous annular

or circular image, though some embodiments intended strictly for panoramic imaging with limited vertical coverage may have a conical exclusion zone toward the front or back.

The more inaccurate definition of omnidirectional relates to the fact that a great circle (such as the horizon) can be imaged by an optical system having a field of view greater than 180 degrees. Such a system is not truly omnidirectional in that it does not have a true 360 degree angle of view. This definition is often used in promotional material for optics which have an angle of view less than 360 degrees, such as in the case of the Peri-Apollar, where the definition is used to incorrectly specify that the optic covers 360 degrees, when in fact it may only cover an annular zone around the horizon plus or minus 30 degrees, for a 240 degree true field of view. According to this definition, all embodiments of the present invention (including those having a central obscuration or conical exclusion zone) would cover 360 degrees. In order to eliminate confusion, the term "Omniramic" (a term probably originated by the applicant) shall be used to describe this type of coverage.

## BRIEF DESCRIPTION OF THE PRESENT INVENTION:

The present invention relates to an optical wide angle optical imaging system, which is made up of both refracting and and reflecting optical surfaces, and which is associated with a camera, projector, medical instrument, surveillance system, robotic system, flight control system, or similar article. More particularly, the present invention is an omnidirectional optical system which consists of an optical substrate having an outer refracting surface, a convex primary reflector surface, a convex secondary reflector surface (in most embodiments), central wide angle refracting optics (in some embodiments), an imaging and correcting lens system which is optically disposed between and in optical communication with the reflector and a focal surface in most embodiments, light baffles, aperture adjustment means, and mechanical mounting components. In embodiments having a secondary reflector surface, the entire space between said secondary surface and said primary reflector surface is typically occupied by the optical substrate. All of these optical surfaces are integrated into a single solid catadioptric optic in some embodiments, but the central wide angle refracting optics and/or the imaging and correcting lens system can be separate optical elements which are associated with the solid optic for other applications. Both the primary and secondary reflectors are typically internal surfaces of the solid optic, so the space between said reflector surfaces is occupied by optical material. This protects the reflective surfaces. One embodiment of the system not having a secondary reflector utilizes an axial strut to support said optical system in front of the lens of a camera or similar article.

Depending on the application, various features of the present invention may be interchanged between all embodiments without departing from the applicant's inventive concept. The degrees of freedom resorted to in different embodiments of the invention may include the materials and manufacturing techniques used to make the invention, the size of the invention, the eccentricity and degree of curvature of the outer refracting surface of the solid

optic, the radial offset (compression, enlargement, or torroidal attribute) of the outer refractive surface figure; the relative size of the primary reflector surface, the degree of curvature and figure of the primary reflector surface, including the eccentricity of an aspheric figure, the radial offset (compression, enlargement, or torroidal attribute) of the primary reflector surface figure, the size and figure of a nonreflective transparent area in the center of the primary reflector surface (in embodiments having a secondary reflector); the size and figure of the secondary reflector surface (or size optical figure of a transparent central exit aperture in embodiments not having a secondary reflector, and whether or not said central aperture supports an axial strut); the spacing between optical surfaces; the existence, size, and figure of a nonreflective transparent area in the center of the secondary reflector the existence, size, and figure of front central refracting optics; the size and configuration of bored, attached, or applied light baffles; the existence, size, configuration, and figure of fixed or steerable periscopic optics to supplement the field of view or provide redundant imaging; the existence and configuration of imaging and correcting optics; whether or not some or all of the imaging optics are an integral part of the solid optical substrate; whether or not the final focal surface is in proximity to the optical system or the image is relayed to it by fiber optics or relay lenses; whether or not aperture adjustment means are provided, the means used for aperture adjustment; the existence and configuration of a side support vane, and wire and fixture routing it may provide; the position and shape of the focal surface relative to the invention, and any combination of these degrees of freedom. Radially compressed, enlarged, or torroidal optical figures are applicable to a variety of applications and optical systems, including those other than the present invention.

The primary differences between embodiments for different applications include overall size; relative sizes of different optical surfaces; materials used; the presence or configuration of moisture and contaminant seals; optimization of the optical figure for immersion, where applicable; and the relative size and longitudinal position of the focal surface.

## SUMMARY OF THE PRESENT INVENTION

The applicant has shown in U.S. provisional application serial number 60/043,701 an improved means for imaging a field of view which is omnidirectional. The present invention is applicable to both original imaging of a subject and for projection of photographic or artificially generated (including computer generated) images. The invention is also applicable to the reception or transmission of light or other radio energy for purposes other than imaging. In this description, the invention will typically be described in terms of an imaging system such as that used with or incorporated into a film or electronic camera.

Obviously, directions traveled by light or other energy will be reversed where the invention is used for projection, and, in the case of applications other than imaging, the subject energy or material will propagate according to the same laws of physics regardless of the direction and whether or not imaging applications are involved.

The invention may be used in many orientations; however, many of its uses relate to simultaneous imaging and projection of an entire 360 panorama which includes a great circle surrounding the invention, said great circle being perpendicular to the optical axis. This is typically accomplished in non medical applications by using the invention in a vertical orientation, in which case, a great circle perpendicular to the optical axis corresponds to a flat horizon. The widest embodiments of the present invention cover an entire sphere on a single focal surface. Three dimensional imaging embodiments cover an entire sphere, providing two or more images thereof on one or more focal surface, whereby elements of each imaged point are imaged from differing vantage points. For clarity, all descriptions of the present invention apply to its use in vertical orientation where its primary reflector surface is facing up.

Improvements of the present invention over the applicant's prior art relate primarily to improved durability; improved compatibility with high air speed environments including use on

missiles or aircraft; miniaturization; increased off-axis resolution; increased vertical coverage; improved compatibility with low cost modes of production, improved durability, and compatibility with a wider array of sensors, cameras, projectors, and other instrumentation.

The primary differences between embodiments having and not having a conical exclusion zone in front of the primary reflector surface is the figure of the outer refracting surface of the solid optical substrate, the figure of said primary reflector surface, the size of any central transparent area in said primary reflector surface, and the size and proximity of a central obstruction such as a secondary reflector surface and its baffle, a sensor, or a separate article such as a camera. Some embodiments having little or no conical exclusion area utilize a radially enlarged primary reflector, said reflector being torroidal in the most extreme of the embodiments. Other embodiments utilize the outer refracting surface of the solid optical substrate, and others utilize a combination of said refracting surface and the primary reflector surface. For a given exclusion zone, radial enlargement of the primary reflector surface results in an angle of reflection which is closer to perpendicular with its optical surface, thereby allowing the angle of refraction of the outer refracting surface to be closer to perpendicular, thereby minimizing or eliminating lateral chromatic aberration from said refracting surface at the affected zones.

In order for the optical system to cover the full sphere around itself when the subject matter is at a finite distance, the annular image produced by said optical system must actually exceed 180 degrees of radial coverage, thereby exceeding 360 degrees of overall coverage. This facilitates the imaging of axial points which are disposed at a finite distance in front and behind the optical system, whereby the axial point in front of the primary reflector surface is imaged as a ring which defines the inner boundary of the annular image formed by said optical system and the axial point behind said primary reflector surface is imaged as a ring which defines the outer

boundary of said annular image. This results in overlapping coverage for subjects at greater distances from the optical system. Where the optical system is utilized under water, an internal primary reflector surface having wider coverage is utilized in order to compensate for reduced refraction from the outer surface of the optical substrate.

The percentage of the image occupied by a central obscuration is also important, since a larger imaged obscuration will result in reduced radial image scale for the rest of the image on a given format. Some embodiments of the optical system reduce the imaged size of any central obscuration by utilizing a radially compressed figure which results in a pointed apex on the reflector surface having the least optical distance from a focal surface. Where the pointed apex is relatively pronounced, the central obscuration is not imaged at all, resulting in a circular image rather than an annular one, and an axial point a finite distance in front of the primary reflector surface is imaged as a point in the center of the circular image. Where the optical system utilizes front central imaging optics in addition to an optical configuration providing means for central coverage in an annular image, the image from said central refracting optics provides redundant coverage of the central area in a circular image which is located within the inner boundary of said annular image.

The invention will be more clearly understood from consideration of the following description in connection with accompanying drawings that form a part of this specification.

## BRIEF DESCRIPTION OF THE DRAWINGS

This section will be supplied with formal drawings. The informal drawings in this application include enough description to facilitate identification. The following description includes blank spaces which will be applicable to many reference numbers which will be in subsequent formal drawings.

## DESCRIPTION OF THE PRESENT INVENTION

The present invention is an improved means for imaging or projecting a field of view which is omnidirectional. The present invention achieves the result of an omnidirectional virtual image __ having a distribution similar to a polar map projection __ by means of a solid optical substrate __ having outer refractive surface __, said surface typically being convex __; an internal convex reflector surface __; and in some embodiments, an internal secondary reflector surface __, said surface typically being convex; and refraction through said solid optical substrate at the axial surface __ closest to a focal surface __; whereby said virtual image is visible from an axial vantage point __ outside the said optical substrate at said axial surface closest to a focal surface.

Correcting optics __ are utilized on most embodiments, said correcting lenses typically correcting for curvature __ of the virtual image __; and aberrations including astigmatism __ which results from low angle reflections __ from the primary reflector surface __ and refraction through the front and rear extremes __ of the outer surface of the solid optical substrate __; and lateral chromatic aberration resulting from refraction through the front and rear zones __ of the outer surface of the solid optical substrate.

Imaging optics __ are utilized between the exit aperture of the solid optical substrate and a focal surface in embodiments providing a real image __ of the subject __ at a focal surface __, by imaging said virtual image __ at said focal surface, said virtual image which is typically beyond the surface of the apex of the secondary reflector surface, said virtual image being a reflection of the virtual image behind the apex of the primary reflector surface; said virtual image behind the apex of said primary reflector surface being imaged directly by said imaging optics in embodiments not having a secondary reflector surface. Correcting optics __ in most embodiments are typically integrated with imaging optics __ in embodiments of the invention which provide a real image at a focal surface.

In some embodiments, the secondary reflector surface __ is utilized to control off-axis aberrations which include astigmatism, whereby said figure is hyperbolic __ in some embodiments, said hyperbolic figure being effective in the control of astigmatism with some combinations of a primary reflector surface and outer refracting surface, provided the other reflective surface and the outer refracting surface are configured to compensate for the radial distribution of the image which would otherwise result from said secondary reflector surface; said means for control of astigmatism being analogous to the control of off-axis aberrations in a Cassegrain telescope, except that the light cone for any given imaged point utilizes a relatively small part of each reflector in the present invention rather than utilizing almost the entire reflector surface as in said Cassegrain telescope; said correcting means resulting in coma in some cases, said coma being corrected with a commercial coma corrector or a similar optical system; refracting optics and the outer refracting surface of the substrate are applicable to correction of aberrations in some embodiments, particularly those not having secondary reflector surface, said refracting optics having characteristics similar to those in a fisheye lens, sans its front element, said characteristics most resembling elements behind the front element of a fisheye lens having a shallow curvature on the front optical surface of said front element; in most embodiments, said outer refracting surface reduces astigmatism at a given angle of view by means of extending the field of view of said primary reflector surface, thereby causing the angle of reflection at outer zones of said primary reflector to be at a greater angle from its surface; appropriate utilization of said outer refracting surface of said solid substrate in the control of astigmatism can also result in a reduction in distortion of the entrance pupil of the overall optical system, particularly in embodiments covering less than a full sphere, where said refracting surface or a separate refracting element either reduces or increases the coverage of said primary reflector, with a decrease in coverage being applicable to reducing the distance between the 180 degree zone of entrance pupils for systems utilizing two opposing optical systems.

Angular distribution of the image is influenced by all of the optical surfaces, with the figure of the primary reflector surface and outer refracting surface having the greatest influence; most of the preferred embodiments produce an image having a constant radial image scale, said embodiments typically utilizing a prolate aspheric primary reflector surface;

The present invention utilizes the elegance of a solid optical substrate __ for optical surfaces utilized in the formation of a virtual image __ of subject matter surrounding it, said substrate also providing alignment and protection of the reflector surfaces.

The present invention provides a wide field of view __ than external reflector systems or the Peri-Apollar by means of utilizing its outer surface __ of its optical substrate __ to extend the field of view of an inner zone its primary reflector surface __ toward the front of the invention __, and extend the field of view of an outer zone of its primary reflector surface __ by means of refraction __, thereby enabling the invention to cover the entire sphere around itself. The solid optical substrate __ provides compactness and improved durability over external reflector systems. Some embodiments provide redundant imaging __ by means of a refracting optical surface __ or system __ which is in optical communication with a focal surface by means of a central transparent area __ in the center of the secondary reflector surface. The optical system further includes baffles __ to eliminate stray light __ and accurately indicate the limits of coverage __ in the image; a grip surface __ to facilitate handling of the optical system without touching its optical surfaces; and means for attachment of accessories __ including one for the occultation of an excessively bright light source such as the sun to reduce or eliminate flare __. The optical system is compatible with a wide array of cameras and other instruments by means of modular optical cells having compatibility with a plurality of common adapters and interfaces for articles having a focal surface, one of said adapters having threads with a 42 mm diameter and a 0.75 mm pitch. The solid optical substrate is compatible with a wide array of fabrication modes and use in a wide range of applications and environments.

In some embodiments, the area directly behind the optical system is redundantly covered by means of one or more auxiliary off-axis optical systems __ facing in the opposite direction of the primary reflector surface, said auxiliary optical system having relay optics __ and reflective means __ to produce a final image at the focal plane, said image being on a common focal plane __ with the annular image, disposed in the center of or immediately beside said annular image; said auxiliary optical system utilizes a steerable housing to facilitate redundant imaging of selected off-axis subject areas at various image scales.

A basic embodiment of the present invention __ utilizes a prolate aspheric reflector surface __. This results in exclusion of a conical area __ in front of the primary reflector surface __, which is caused by obscuration by a secondary reflector surface __, a camera __, or a transparent zone in the primary reflector.

A front exclusion zone is completely eliminated by means of a torroidal primary reflector __ and a small convex secondary reflector __ having a diameter less than the diameter of the apex of the torroid of said primary reflector. Elimination of the front conical exclusion zone is accomplished by redundantly imaging the part of the subject __ a finite distance directly in front of the primary reflector __ at the radial zone of the annular image circle __ which is closest to the center by means of a primary reflector having a torroidal figure __ combined with a secondary reflector assembly __ having a diameter smaller than the torroidal apex __ of said primary reflector. The remainder of the subject __ is progressively imaged toward the outer edge of the annular image __. Optical surfaces used to accomplish this consist of a strongly curved prolate aspheric primary reflector __, a moderately convex secondary mirror __, and rear imaging optics __. The secondary reflector surface __ is in optical communication __ with both the primary reflector surface __ and the imaging lens system __ which is located behind a central transparent zone __ in said primary reflector surface.

A miniature version of the invention is applicable to articles such as surgical instruments, dental instruments, bore sights or scopes, and other articles; the present invention being very useful for such applications, particularly in the realm of laparascopic surgery, due to its omnidirectional field of view.

Images having various radial distribution characteristics are produced according to the profile of the external surface of the optic. One covers all the way to an axial point a finite distance in front of the primary reflector by refracting light around the secondary reflector surface. Another does not cover the central area but results in little or no refraction in its central zones, thereby minimizing or eliminating chromatic aberration, and particularly lateral chromatic aberration at said zones; where required, central coverage is provided by a central refracting optical system which is in optical communication with a focal surface or observational vantage point by means of a central transparent area in the center of the secondary reflector surface. Where a torroidal primary reflector surface is utilized, the inner zones of said primary reflector surface can be in optical communication with an axial point a finite distance in front of its surface with minimal or no refraction in the applicable zones of the outer refractive surface, where said surface is normal to the light path, thereby reducing or eliminating lateral chromatic aberration at the applicable zones and facilitating central coverage even when the optical system is used under water or in other immersion environments. Embodiments not having a secondary reflector surface can utilize a central refracting optical system which is in optical communication with a focal surface or observational vantage point by means of a central transparent area in the center of the reflector surface to provide central coverage, said coverage being particularly useful in medical and immersion applications.

The optical system is applicable to the omnidirectional expansion of lasers and other light sources for communications, switching, opto isolation, illumination, holographic imaging and projection, and other applications.

The diameter of a central transparent zone in the primary reflector surface can be increased or its surface can have negative optical power, facilitating unobstructed optical communication between a relatively large secondary reflector surface and an imaging lens system which is closer to the focal plane, thereby facilitating a faster numerical f/ratio for said imaging lens system; where the figure of the primary reflector surface is radially enlarged, said larger central transparent area will not result in any reduction of coverage.

In most two reflector (Cassegrain) embodiments, the optical substrate occupies the entire area between the primary and secondary reflector surfaces. A two reflector system results in an unreversed image and allow the camera and photographer to be behind the primary reflector, where exclusion from the image is easier in embodiments not having full sphere coverage. Reflective coatings are typically used on both reflector surfaces. These coatings can be aluminum for many applications, but rhodium is applicable to certain environments and god or other coatings are optimal for selected wavelengths. The optical system is also applicable to a two reflector (Cassegrain) wide angle reflector system in which only one of the reflector surfaces is internal.

The invention is applicable to a self-contained electronic or film imaging system, said self contained system being very advantageous in small embodiments having full sphere coverage, since the perimeter of a full sphere system having a contiguous image must be larger than the width of a camera or similar article which is used with it in order to prevent obscuration of the subject by said camera.

The optical system may utilize a rotating camera adapter for rotation of the unit to place the aperture control in a convenient position, said adapter consisting of lock rings where focus adjustment is required in an inexpensive system; said camera adapter incorporating a slot around its circumference which facilitates storage and transportation in a case without contact to any

optical surfaces; said camera adapter accepting filters and auxiliary imaging optics, whereby different optics are in interchangeable cells which will allow one size and configuration of reflector unit to be adapted to a wide variety of camera formats, projectors, and other instruments, whereby, a short tube tube of the proper length typically houses a strong positive lens, a slightly long tube houses a weaker positive lens, and an even longer tube would house no lens, and a yet longer tube would house a negative lens, said tubes being used singly or in combination with the solid optical system to adapt same reflector unit to different format cameras while not necessarily requiring recalibration of focus.

A self-contained embodiment having an imaging lens will fit directly on a camera body

An embodiment having a weak positive close up lens system may be used in front of a camera having a fixed or interchangeable with its lens.

The optical system is applicable to omnidirectional image projection in virtual reality headsets, booths, suites, theaters, work stations, simulators, or other environments.

Most embodiments utilize a smooth optical surface for the outer refracting surface, though a Fresnel surface is applicable to some specialized applications, said Fresnel surface being turned, molded, or produced by other means; where produced by turning, said Fresnel surface may be turned on a numerically (computer) controlled machine, said machining having a numerically controlled rotating tool for turning said Fresnel surface, whereby a flat face on said rotating tool is rotated according to the desired angle of a given Fresnel zone, said Fresnel surface being turned concentrically or spirally, said zones on Fresnel surface having a fat profile or one which is slightly curved to produce refraction according to all or part of the radial angle of view covered by the surface of said Fresnel zone.

Grinding and polishing, turning, molding, or other means are applicable to fabrication of the solid optical substrate. Where precision molded plastic optics are utilized, the solid optical

substrate of some embodiments can be molded with a simple two piece mold or die; other embodiments can be molded with more complex dies or in multiple pieces, said multiple pieces either being separated diagonally, on a plane perpendicular to the optical axis, or on a plane or planes radial to the optical axis; additionally, curved joints can be utilized rather than flat ones, whereby said joints are more easily concealed, said curved joints being symmetrical or asymmetrical with the optical axis; where the substrate is made in three sections separated more or less radial to the optical axis, said joints can be spiral.

The concept of widening the field of view of a given reflector by means of refraction through an optical substrate is also applicable to the use of refracting elements which are separate from the reflector, as in the claimed embodiment where a reflector of moderate coverage is surrounded by an annular (or semi-torroidal by some definitions) optical element having a radial cross section similar to that of the front element of a fisheye lens; in some embodiments, the apex of said reflector is positioned near the longitudinal center of said annular optic.

An outer refracting surface or element is applicable to extending the field of view of an existing or custom hyperhemispherical fisheye lens, where the internal surface of the substrate has a hyperhemispherical void rather than a reflecting surface and said fisheye lens is positioned inside, with its front element just in front of the rear limit of said hyperhemispherical curve.

--- Please see accompanying document for more material to support the claims herein for the optics, projection surfaces, and interfaces which comprise the present invention -----

This disclosure is considered as illustrative of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction, operation, and appearance as shown and

described, and accordingly all suitable modifications and equivalents may be resorted to without thereby departing from the basic principles of the invention. It will be further understood that the invention is susceptible of embodiment in many various forms, some of which are illustrated in the accompanying drawings, and that structural details and modes of fabrication herein set forth may be varied and interchanged to suit particular purposes and still remain within the applicant's inventive concept.

What is claimed is:

1. An optical system comprising:

* a solid optical substrate having a convex outer refracting surface, said surface covering most of the front and side of said substrate,
* said substrate having an internal convex primary reflector surface of radial symmetry,
    * said primary reflector surface being in optical communication with a great circle surrounding it, the plane of said great circle being perpendicular to the optical axis of said optical system, said optical communication being through the outer refractive surface of said substrate,
    * said primary reflector surface having sufficient curvature to be in optical communication with a substantial area in front of and behind the plane of said great circle,
    * said primary reflector surface having an optically transparent central zone,
* said substrate also having an internal secondary reflector surface of radial symmetry,
    * said secondary reflector surface being coaxially disposed in front of said primary reflector surface,
    * said secondary reflector surface having its reflective surface facing said primary reflector surface,
    * said secondary reflector surface being in optical communication with said great circle surrounding said primary reflector surface and said area in front and behind the plane of said great circle by means of reflection from

said primary reflector surface and refraction through the outer surface of said substrate,

* whereby said optical system produces a virtual image of said great circle and said area above and below its plane, said virtual image being annular,
    * said virtual image being visible from a vantage point behind said optically transparent central zone of said primary reflector surface due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said secondary reflector surface and said primary reflector surface and refraction through the outer surface of said substrate;
* means for mounting said substrate,
    * said means for mounting providing a protective shield behind the perimeter of said substrate,
    * said means for mounting also having provision for handling the optical system without touching its optical surfaces;
    * said means for mounting providing stable support and alignment of said substrate without causing deformation thereof,
    * said means for mounting providing for attachment of said optical system to an article having a focal surface,
    * said mounting means facilitating use of said optical system in any orientation,
    * said optical system being associated with a refracting lens system, said refracting lens system being disposed coaxial to said optical system, both being associated with the formation of a real image of said virtual image at said focal surface,

whereby said optical system when combined with said article having a focal surface facilitate the geometric conversion of said great circle and said area in front and behind the plane of said great circle into a real annular image at the focal surface of said article and vice versa,

2. apparatus according to claim 1 where the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution being nearly perpendicular to the light path at a zone just outside the perimeter of the secondary reflector surface and its baffle, whereby lateral chromatic aberration at said zone is negligible, whereby lateral chromatic aberration in the virtual image from the overall system will increase as a function of off-axis distance, thereby facilitating correction of lateral chromatic aberration by means of relatively conventional correcting optics or by separating a real image into separate colors and individually scaling each color separation,

3. apparatus according to claim 1 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having an angle of incidence to the light path at a zone just outside the perimeter of the secondary reflector surface and its baffle, whereby a zone in front of said optical system that would otherwise be obscured by said secondary reflector surface and its baffle is imaged by means of being in optical communication with said primary reflector surface by refraction through said zone in said substrate, thereby extending the angle of view toward the front of the invention,

4. apparatus according to claim 1 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having a substantial angle of incidence to the light path at a zone just outside the perimeter of the secondary reflector surface and its baffle, whereby an axial point disposed a finite distance in front of said optical system is imaged by means of being in optical communication with said primary reflector surface by refraction through said zone in said substrate, thereby extending the angle of view all the way

around the front of the invention,

5. apparatus according to claim 1 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution extending to a longitudinal position behind that of the perimeter of said primary reflector surface, said surface of revolution having an angle of incidence to the light path at a zone just outside and behind the perimeter of said primary reflector surface, whereby a zone behind of said optical system that would otherwise be beyond the limit of coverage for said primary reflector surface is imaged by means of being in optical communication with said primary reflector surface by refraction through said zone in said substrate, thereby extending the angle of view toward the rear of the invention,

6. apparatus according to claim 1 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution extending to a longitudinal position behind that of the perimeter of said primary reflector surface, said surface of revolution having an angle of incidence to the light path at a zone just outside and behind the perimeter of said primary reflector surface, whereby an axial point a finite distance behind said optical system is imaged by means of being in optical communication with said primary reflector surface by refraction through said zone in said substrate, thereby extending the angle of view all the way around the rear of the invention,

7. apparatus according to claim 4 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution extending to a longitudinal position behind that of the perimeter of said primary reflector surface, said surface of revolution having a substantial angle of incidence to the light path at a zone just outside and behind the perimeter of said primary reflector surface, whereby an axial point a finite distance behind said optical system is imaged by means of being in optical communication with said primary reflector surface by refraction through said zone in said substrate, resulting in coverage of the entire sphere around said optical system,

8. apparatus according to claim 1 in which said outer refracting surface is comprised of a plurality of scallops which are concave as seen from the front but convex as seen from the side, refraction through said scallops causing the area occupied by each scallop to have more than twice the included angle as the angular circumference of the optical surface it occupies; for example, as seen from the front, each scallop of a twelve scallop optical system would occupy 30 degrees of the circumference as seen from the front; therefore, each of said scallops would provide more than 60 degrees of coverage; said optical system providing a sectored virtual image, said image having the same number of sectors as said refracting surface has scallops, each of said scallops covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points, said points being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage; said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system also being applicable for the basis of image processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, (not supported by the applicant's provisional applications)

9. apparatus according to claim 1 in which the figure of said outer refracting surface is optimized to minimize flare and ghost images,

10. apparatus according to claim 1 in which the outer refracting surface of said substrate has anti reflection coatings,

11. apparatus according to claim 1 in which said primary reflector surface and said secondary reflector surface have reflective coatings which facilitate efficient reflection at a wide range of incident angles, including angles not subject to total internal reflection,

12. apparatus according to claim 1 in which the perimeter of said optical system provides means for accurately indicating the limits of the image it produces,

13. apparatus according to claim 1 in which said primary reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure,

14. apparatus according to claim 1 in which said primary reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, whereby the image produced by the overall optical system has a constant radial image scale,

15. apparatus according to claim 1 in which said primary reflector surface comprises a surface of revolution, said surface of revolution being radially compressed inward toward the optical axis, whereby the surface said primary reflector surface is farther from being perpendicular with the optical axis at a zone which immediately surrounds said transparent central zone, whereby said vantage point behind said transparent central zone of said primary reflector surface is in optical communication with a smaller angular area in front of said great circle, thereby increasing the size of a central angular exclusion zone in front of said primary reflector surface while minimizing the physical size of said obscured area imaged at said focal surface, thereby increasing radial proportions of the imaged area immediately surrounding the plane of said great circle, thereby resulting in a larger radial image scale for said area covered on a given image format, owing to the reduced relative size of an imaged central obscuration area,

16. apparatus according to claim 2 in which said primary reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being radially enlarged outward from the optical axis, whereby the surface

said primary reflector surface is closer to perpendicular with the optical axis at a zone which immediately surrounds said transparent central zone, whereby said vantage point behind said transparent central zone of said primary reflector surface is in optical communication with a greater angular area in front of said great circle, thereby reducing the size of the central angular exclusion zone in front of said primary reflector surface, said radially enlarged primary reflector surface also permitting said transparent central zone to be enlarged without affecting the field of view, whereby said enlarged transparent zone permits the use of large aperture refracting and correcting optics such as those associated with a camera or a projector, said secondary reflector surface being relatively small in order to minimize obscuration of subject matter in front of said primary reflector surface, whereby said combination of attributes typically result in a reduced conical obscuration area,

17. apparatus according to claim 2 in which said primary reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being torroidal as a result of being radially enlarged outward from the optical axis, whereby said primary reflector surface curves backward in the zone immediately surrounding said transparent central zone, whereby the radial zone of said primary reflector surface by which the inner zone of said secondary reflector surface is in optical communication with an axial point disposed at a finite distance in front of said optical system by means of reflection from said zone of said primary reflector surface has a larger diameter than said secondary reflector surface and its baffle, whereby said vantage point behind said transparent central zone of said primary reflector surface is in optical communication with the entire area in front of said great circle up to said axial point disposed at a finite distance in front of said primary reflector surface, thereby eliminating the central angular exclusion zone in front of said primary reflector surface when said optical system is used in air or immersed in a liquid media,

the only excluded area being confined to a narrow conical area extending from the perimeter of said secondary reflector surface with its associated mounting and shielding to said axial point disposed a finite distance in front of said primary reflector surface, said torroidal primary reflector surface also permitting said transparent central zone in said primary reflector surface to be enlarged without affecting the field of view, said enlarged transparent zone permitting the use of large aperture refracting optics such as those associated with a camera or projector,

18. apparatus according to claim 1 in which said primary reflector surface is scalloped, resulting in a plurality of identical convex lobes disposed evenly around its circumference, each lobe having more than twice the included angle as the angular circumference of the reflector surface it occupies; for example, as seen from the front, each lobe of a twelve lobe reflector surface would occupy 30 degrees of the circumference; therefore, each of said lobes would have more than 60 degrees of curvature as seen from the front; said primary reflector surface providing a sectored virtual image, said image having the same number of sectors as said primary reflector surface has lobes, each of said sectors covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points, said points being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage; said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system also being applicable for the basis of image processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

19. apparatus according to claim 18 in which said scalloped primary reflector surface is comprised of a plurality of scallops which are concave as seen from the front but convex as seen from the side rather than having convex lobes, said scallops having the same degree of coverage as said convex lobes,

20. apparatus according to claim 1 in which the secondary reflector surface is convex, further comprising an annular reflector surface which is coaxial with said secondary reflector surface, said annular reflector surface having sufficient curvature to cover the same area in front and behind said great circle as said primary reflector surface, including the effects of said outer refracting surface on both reflector surfaces, said annular reflector surface having a longitudinal position which places its virtual image in close longitudinal proximity to that of said virtual image from said primary reflector surface as reflected in said secondary reflector surface, said virtual image from said annular reflector surface being visible from a vantage point behind said optically transparent central zone of said primary reflector surface due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said annular reflector surface, said annular reflector surface providing redundant coverage, said redundant coverage providing three dimensional information for the entire area of coverage, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

21. apparatus according to claim 18 in which said secondary reflector surface is convex, further comprising an annular reflector surface which is coaxial with said secondary reflector surface, said annular reflector surface having sufficient curvature to cover the same area in front and behind said great circle as said primary reflector surface, including the effects of said outer refracting surface on both reflector surfaces, said annular reflector surface having a longitudinal position which places its virtual image in close longitudinal proximity to that of said virtual

image from said primary reflector surface as reflected in said secondary reflector surface, said virtual image from said annular reflector surface being visible from a vantage point behind said optically transparent central zone of said primary reflector surface due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said annular reflector surface, said annular reflector surface providing redundant coverage, said redundant coverage providing three dimensional information in all axes of the entire area of coverage, (not supported in provisional applications)

22 apparatus according to claim 18 in which an annular reflector surface which is coaxial with said secondary reflector surface is scalloped, thereby allowing said optical system to provide redundant sectored images said redundant coverage providing three dimensional information in all axes of the entire area of coverage, (not supported in provisional applications)

23. apparatus according to claim 1 in which said secondary reflector surface is surrounded by a baffle, said baffle preventing stray light from entering said optical system around the perimeter of said secondary reflector surface, said baffle also providing accurate indication of the inside limit of the annular image produced by said optical system, said baffle being provided by an attached part, an opaque coating applied to said substrate, a blackened annular depression in said substrate surrounding said secondary reflector surface, a blackened annular depression in said substrate surrounding said central transparent area in said primary reflector surface, or other means,

24. apparatus according to claim 1 in which said secondary reflector surface is a convex surface of revolution,

25. apparatus according to claim 1 in which said secondary reflector surface is a convex surface of revolution having a figure which is radially compressed inward toward the optical axis in order to facilitate an unchanged field of view while not imaging said central transparent area in center of said primary reflector surface, thereby allowing the radial image scale of the covered area to be increased owing to the virtual absence of imaged central obscuration area, said convex secondary reflector surface also providing for the correction of off-axis aberrations,

26. apparatus according to claim 1 in which the figure of said secondary reflector surface is an aspheric surface of revolution providing means for the substantial correction of off-axis astigmatism which results from off-axis reflections off of said primary reflector surface and refraction through said outer surface of said substrate, said apparatus further comprising refracting optics which are coaxial with said primary reflector surface and behind said transparent central zone of said primary reflector surface, said refracting optics providing means for correction of residual aberrations from said primary reflector surface and said secondary reflector surface, (not supported in provisional applications)

27. apparatus according to claim 1 in which said secondary reflector surface is on a separate optical component, said secondary reflector and the surface of said substrate being between said secondary reflector and said primary reflector surface providing means for correction of off-axis aberrations,

28. apparatus according to claim 27, in which additional refracting optical components are used between said secondary reflector and said substrate of said optical system,

29. apparatus according to claim 1 in which said secondary reflector is a separate optical component, said secondary reflector having a transparent substrate, having its reflective surface on the side opposite said primary reflector surface, the side of said substrate toward said primary reflector surface also having a surface of revolution and acting as a refracting surface, said refracting surface surface of said secondary combined with the refracting surface of said

substrate of said optical system which is between said secondary reflector and said primary reflector surface providing means for the substantial correction of off-axis astigmatism and lateral chromatic aberration, said optical system further comprising refracting optics which are coaxial with said primary reflector surface and in longitudinal proximity to said transparent central zone of said primary reflector surface, said refracting optics correcting for residual aberrations from other optical surfaces, (not fully supported in provisional applications)

30. apparatus according to claim 29, in which additional refracting optical components are used between said secondary reflector and said substrate of said optical system,

31. apparatus according to claim 2 in which said secondary reflector surface has an optically transparent central zone, said central zone having a concave figure as seen from the front, said central zone refracting light, whereby the angle of view obscured by said secondary reflector surface and its baffle is covered by said transparent central zone, said coverage being inside the annular image formed by the rest of said optical system,

32. apparatus according to claim 7 in which said secondary reflector surface has an optically transparent central zone, said central zone having a concave figure as seen from the front, said concave central zone refracting light, whereby a substantial angle of view is covered by said transparent central zone, said coverage being inside the annular image formed by the rest of said optical system, said coverage also being redundant,

33. apparatus according to claim 1, in which said secondary reflector surface has an optically transparent central zone, said optical system also having an refracting lens system disposed axially in front of said optically transparent central zone in said secondary reflector surface, whereby the angle of view obscured by said secondary reflector surface and its baffle is covered by said refracting lens system and any refraction through an optimized transparent central zone in said secondary reflector surface, said coverage being inside the annular image formed by the rest of said optical system, said system also incorporating a neutral density

filtration to equalize the brightness of images from said central refracting system and the rest of the optical system,

34. apparatus according to claim 33 in which said wide angle refracting lens is attached to center of said solid optic in a way that allows the front outer surface of the entire optical system to be uninterrupted at the boundary between both optical elements, said boundary being sealed against moisture and other contamination,

35. apparatus according to claim 33 in which a cell is attached to the front center of said solid optical substrate, said cell having mounting means for said refracting lens system which provides calibrated longitudinal positioning means for one or more elements of said central wide angle refracting lens system in order to adjust the radial field of view of said lens system to compensate for parallax in the radial zone of transition between the subject area covered by said refracting lens system and the annular image produced by said solid optical system, said adjustment providing parallax compensation at said transition zone for close subject distances,

36. apparatus according to claim 1 in which said secondary reflector surface has an optically transparent central zone, said optical system also having a cell attached to the front center of said solid optical substrate, said cell having mounting means for interchangeable optical systems which can be utilized to image or project the central part of the subject at varying image scales, said interchangeable optical systems also incorporating optional means to be positioned independent of said solid optic in order to image various parts of the subject which are not necessarily at the center, said mounting means providing calibrated longitudinal positioning means for one or more elements of said central interchangeable lens system in order to adjust the focus or the radial field of view of said lens system.

37. apparatus according to claim 11 in which said central transparent zone in said primary reflector surface consists of a hole in the reflective coating, the surface of said substrate being radially symmetrical within said hole in said reflective coating,

38. apparatus according to claim 1 in which refracting surfaces of said substrate are used in the control of aberrations,

39. apparatus according to claim 1 in which said transparent area in center of said primary reflector surface is curved to act as a negative refracting surface in order to increase the apparent optical distance between said secondary mirror surface and said rear imaging lens system, thereby allowing an unobstructed view of a larger secondary mirror surface from said rear imaging optics without increasing the diameter of said transparent area in center of said primary reflector surface, said optical system also having a substantially larger secondary reflector surface than what is shown on any of the drawing figures, said secondary surface being either curved or flat, depending on its size and the application,

40. apparatus according to claim 1, in which said central transparent area in said primary reflector surface comprises a refracting surface of negative optical power, whereby said refracting surface provide for said vantage point behind said optically transparent central zone of said primary reflector surface to be moved to a substantial axial distance behind said transparent central zone, thereby allowing unobstructed optical communication between said moved vantage point and the entirety of said secondary reflector surface while allowing said transparent central zone of said primary reflector surface to have a relatively small diameter,

41. apparatus according to claim 1 in which said central transparent area in said primary reflector surface protrudes behind said primary reflector surface.

42. apparatus according to claim 41 in which said transparent extension of said solid optic which protrudes back from center of said primary reflector surface includes a curved rear refracting surface capable of causing all rays behind the overall optical system to be parallel, enabling said optical system to be used in front of a lens for a camera or other article which is focused at or closer than infinity,

43. apparatus according to claim 1 in which said substrate provides support and alignment of said outer refracting surface, primary reflector surface, and secondary reflector surface,

44. apparatus according to claim 7 in which said primary reflector surface alone has a field of view of more than 265 degrees when viewed from a point approximately equal to its own diameter above its apex,

45. apparatus according to claim 1, further comprising a durable rim behind the perimeter of said primary reflector surface, said rim having a slightly larger diameter than said reflector surface and, said rim providing protection for said primary reflector surface and serving as a grip surface to permit handling said optical system without soiling the optical surface, said rim also being connected to the mounting means for said article having a focal surface, said means for mounting and said rim also having provision for the attachment of accessories such as a clear storage and composition tube, a solar occulting object, a level indicator, and data display devices, said level indicator and display devices being directly visible and imaged at said focal surface of said article,

46. apparatus according to claim 1 in which said substrate is transparent plastic, said substrate also extending behind the perimeter of all reflecting and refracting optical surfaces and providing a protective rim behind said optical surfaces as well as a grip surface to facilitate handling without touching or marring said optical surfaces,

47. apparatus according to claim 1 in which said substrate is transparent plastic, the outer refracting surface of said substrate having a total curvature of slightly less than 180 degrees, said substrate being precision molded plastic;

48. apparatus according to claim 7 in which said substrate is transparent plastic, the outer refracting surface of said substrate having a total curvature of more than 180 degrees, said substrate also extending behind the perimeter of all reflecting and refracting optical surfaces and providing a protective rim behind said optical surfaces as well as a grip surface to facilitate

handling without touching or marring said optical surfaces, the outer refracting surface of said substrate being fabricated by modes which include molding or turning,

49. apparatus according to claim 1, further comprising refracting optics, said refracting optics being coaxial with and having a diameter smaller than said primary reflector surface, said means for mounting including a cell for said refracting optics, said means for mounting positioning said refracting optics between said transparent central zone in said primary reflector surface and the focal surface of said article, said refracting optics being in unobstructed optical communication with both, said refracting optics being in optical communication with said great circle surrounding said primary reflector surface by means of refraction through the outer surface of said substrate and reflection from said primary reflector surface and said secondary reflector surface, said refracting lenses having a longitudinal position corresponding to said vantage point, said longitudinal position of said vantage point being variable according to the embodiment and application of said optical system,

50. apparatus according to claim 49, further comprising a series of refracting lenses in interchangeable cells which are each capable of producing a real image from the overall optical system at a focal surface, said cells being of appropriate lengths to produce proper focus and image size at said focal surface when used with the intended articles having a focal surface, said cells also incorporating adaptation and mounting means for appropriate standardized adapters and camera and instrumentation mounting interfaces,

51. apparatus according to claim 49 in which said refracting lenses are capable of producing a real annular image of the virtual image resulting from reflections off said primary reflector surface and said secondary reflector surface, said real image being at or relayed to the focal surface of said article; mounting means for said refracting lenses also providing aperture adjustment means, focus adjustment means, and a filter holder, as required; said article being a camera, projector, medical instrument, or other device,

52. apparatus according to claim 49 in which said refracting lenses are of the zoom type, whereby images of different sizes are produced by adjusting the focal length of said zoom lens, whereby the same optical system can be used advantageously with different formats,

53. apparatus according to claim 49 in which the overall optical system has an exit pupil, said refracting optics causing paraxial light rays behind said optical system to be parallel, enabling said optical system to be used in front of an article having a focal plane where said article has a lens focused at and slightly closer than infinity, said optical system being compatible with cameras and projectors having fixed lenses, thereby enabling said optical system to be used afocally in front of said fixed lenses,

54. apparatus according to claim 1, also comprising a refracting lens system immediately behind said transparent central zone of said primary reflector surface, said lens system having increasing positive optical power toward its perimeter, said refracting lens system correcting for field curvature,

55. apparatus according to claim 49 in which said refracting optics substantially correct curvature of the virtual image resulting from reflections off said primary reflector surface and said secondary reflector surface, thereby facilitating the optimum use of a flat focal surface, said refracting optics typically comprising at least one lens, at least one of which has negative optical power, said negative lens being positioned in relatively close proximity to said focal surface, further, where the application permits, said negative lens can be in contact with or virtually in contact with said focal surface, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

56. apparatus according to claim 55 in which an existing achromatic Barlow lens design is used as the field flattener, (not supported in provisional applications)

57. apparatus according to claim 49 in which said refracting lenses and other optical surfaces substantially correct aberrations such as off-axis astigmatism which result from off-axis reflections off of said primary reflector surface and said secondary reflector surface, as marginally supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

58. apparatus according to claim 49 in which said refracting lenses substantially correct primary and residual aberrations from said solid transparent optical substrate, said primary reflector surface and said secondary reflector surface, said corrected aberrations including lateral chromatic aberration; said optics also forming a real image of said virtual image at said focal surface and vice versa, (Remarks: this optical system is that of the title of U.S. provisional application 60/043,701, filed April 16, 1997)

59. apparatus according to claim 49, in which one or more elements in said imaging and correcting optics have discontinuous aspheric curves which may include an annular deviation in its figure (similar in concept to a Schmidt corrector but more pronounced) which is utilized in correcting aberrations from said substrate, said aberrations including bidirectional lateral chromatic aberration and astigmatism, said reflector surfaces having a figures which are used in the control of astigmatism and correction for spatial distortion in the annular image caused by said annular figure of said imaging and correcting optical element; thereby facilitating sharp images and a relatively fast numerical f/ratio, (not supported in provisional applications)

60. apparatus according to claim 49 in which said transparent area in center of said primary reflector surface is concentric with the optical center of said refracting optics,

61. apparatus according to claim 49 in which said means for mounting include a central cell, said cell protruding back behind said primary reflector surface, said protruding cell having a slot around its circumference which may be used to attach accessories and facilitate storage of the

overall optical system in a case without any optical surfaces being in contact with said case, said cell being capable of supporting the weight of the entire optical system, attributes of said cell including said slot providing means to attach devices including a solar occulting disk, a level indicator, and data display devices; said level indicator and display devices being directly visible and imaged at said focal surface of said article having a focal surface, said cell also having provision to house said refracting lenses, said cell further comprising a filter holder,

62. apparatus according to claim 49 in which said rear imaging optics and a focal surface are recessed inside the hollow area behind said primary reflector surface, whereby the position thereof facilitating better performance with a given numerical f/ratio and sophistication of correcting optics,

63. apparatus according to claim 49 in which said article having a focal surface and its lens are located behind said transparent area in center of said primary reflector surface, enabling said article and its lens to directly view the virtual image from said secondary reflector surface and form a real image from the overall optical system at said focal surface, the longitudinal position of said article and lens being variable in order to allow said camera and lens to either be recessed inside the hollow area behind said primary reflector surface or positioned behind the overall optical assembly, said overall optical system not including its own rear imaging optics.

64. apparatus according to claim 1, further comprising an occulting attachment consisting of a small darkened occulting body (typically a sphere) which is affixed to the end of a thin wire of sufficient rigidity to prevent oscillation of said occulting body by wind or moderate motion, said attachment providing for reduction of flare by interrupting specular optical communication between a bright light source such as the sun and the focal surface of said article, said occulting body typically having an angular subtense at least one degree larger than said bright light source as seen from the corresponding area of said virtual image from said primary reflector surface, thereby causing the image of said occulting body to completely cover said bright light source in

the image formed by said optical system, said occultation resulting in a drastic reduction in unwanted reflections and flare; said means for mounting having provision for attaching said occulting attachment to either the front of said optical substrate or a rim surrounding an area behind said primary reflector surface, said mounting means also providing for adjustment of said occulting body position,

65. apparatus according to claim 1, further comprising a level indicator which is attached in close proximity to and slightly behind the perimeter of said primary reflector surface, said level indicator having easily distinguished indication means when observed from above and below, said secondary reflector surface being larger than what is required to image said primary reflector surface alone, said secondary reflector baffle providing means for optical communication between said level and the focal surface of said article, said level being imaged at said focal surface by means of reflection via said secondary reflector, whereby said level is visible in the image and the viewfinder of a single lens reflex camera, thereby facilitating effective hand held use of the optical system since the photographer and said camera or similar article are behind said primary reflector surface, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

66. apparatus according to claim 1, further comprising an integral level indicator or window for viewing a level indicator, whereby said level indicator which is visible in the image (and thereby in the viewfinder of a camera) and from an external position, said visibility in the image being accomplished by said indicator being positioned outside the perimeter of said primary reflector surface but within the perimeter of the outer refracting surface of said substrate, said level indicator also being behind the longitudinal position of the perimeter of said primary reflector surface, said level indicator being visible in said image by total internal reflection from the solid optical substrate, where the vantage point is in optical communication with the camera directly from a camera or by reflection from secondary reflector surface, depending on the

embodiment; said level being visible directly by looking through the outer refracting surface of said substrate; said level indicator also observable through the rear of said invention in embodiments where the rear of said level indicator and its enclosing structure are transparent, (Not in applicant's provisional application 60/043,701. Remarks: Total internal reflection from the outer refracting surface is avoided in the imaging system itself.)

67. apparatus according to claim 7 in which said secondary reflector surface has an optically transparent central zone, said optical system further comprising a level indicator which is visible through said transparent central zone, whereby said level indicator is visible in the image produced by the invention,

68. apparatus according to claim 1, further comprising a periscopic optical system which points directly behind said optical system, said periscopic optical system being attached to said optical system at a point between the back of said primary reflector surface and the front of said article having a focal surface, said attachment means including a hollow tube, mirrors, and relay optics, said periscopic optical system having a circular field of view greater than the conical exclusion zone behind said primary reflector surface, the image from said periscopic optical system being imaged at a common focal surface with the annular image from said optical system, but in an area not occupied by said annular image, whereby the overall optical system images the entire sphere around itself on a single focal surface; further, the use of a beam splitter on a transparent support which is in proximity to said focal surface will allow said circular image to be imaged in the center of said annular image,

69. apparatus according to claim 1, associated with (attached to or incorporated into) a camera, photographic optical system, electronic image system, motion picture system, surgical instrument, endoscope, bore scope, surveillance instrument, robotic device, microphone, speaker, or similar article, said article incorporating means for providing illumination of the subject where and as dictated by the application, subject illumination means being located

behind said primary reflector surface and in front of said secondary reflector surface, said lighting means being shielded so as not to directly strike the optics in order to reduce flare; and where electronic flash is used, said flash in front of said secondary reflector surface is triggered by a photosensitive slave sensor in order to eliminate wiring, said flash illumination being compatible with still and motion images, (Remarks: Lighting from behind primary addressed in U.S. provisional application 60/043,701; other aspects of lighting not fully supported in provisional applications)

70. apparatus according to claim 69, associated with an electronic imaging sensor, provision of subject illumination means also employing a range gated imaging by means of a sensor exposure of only a few to a few dozen nanoseconds, which in turn results in a shorter effective exposure for objects nearest the optical system; further provision thereof in which illumination is actually directed through said optical system by means of a beam splitter prior to the initiation on an exposure.

71. apparatus according to claim 1, further comprising an electronic imaging sensor capable of exposure and readout without mechanical shuttering, said optical system being capable of imaging the entire sphere around itself; said imaging being accomplished without any moving parts;

72. apparatus according to claim 71, said combination also having provision and interface capability to facilitate real time digital processing of more than 23 images per second, whereby said optical system may also be associated with a separate full motion imaging system, (motion pictures covered in both provisional applications, but digital may not have been specified)

73. apparatus according to claim 4 in which a round baffle may be attached to said substrate, said round baffle having longitudinal positioning means, whereby the shadow of said round baffle changes the distance of said axial point disposed a finite distance in front of said primary reflector surface, thereby providing means for said axial point to coincide with a front projection

surface, thereby resulting in a seamless projection across the central part of a projection surface having a finite distance from said optical system, said apparatus being associated with the projection of images which completely surround the viewing participant, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

74. apparatus according to claim 1, whereby said optical system is associated with a projector and a spherical or semi spherical projection surface to facilitate the geometric conversion of an annular image into a spherical projection around said optical system, said convex primary reflector surface having a strong aspheric figure which, in conjunction with said outer refracting surface, facilitates correct image proportions and constant projection brightness throughout the surface of a spherical or semi-spherical projection area, said primary reflector surface compensating for varying distances to said projection area and the position of said primary reflector surface relative to said projection surface, said apparatus being applicable to applications including virtual reality headsets, games, simulators, booths, suites, and theaters, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

75. apparatus according to claim 1, embodied in any size laparascopic surgical or observation instrument, endoscope, sigmoidoscope, bore scope, camera, projector, surveillance instrument, flight control system, robotic device, or similar article, said article incorporating means for providing illumination of the surrounding area, where and as dictated by the application,

76. apparatus according to claim 1 in which a laparascopic or other article includes electronic imaging means and has means for providing adaptation and computer interface capability to facilitate substantial real time digital processing of the image,

77. apparatus according to claim 1 in which two such omnidirectional optical systems are incorporated into a single instrument, said optical systems being pointed in opposite directions

in order to provide redundant coverage of the entire subject with opposing image projections, resulting in reduced distortion of many parts of the subject without resorting to external image processing,

78. apparatus according to claim 77 in which two such omnidirectional optical systems are incorporated into a single instrument, one or more of said optical systems being independently positionable in order to provide redundant coverage of the entire subject with configurable image projections, resulting in reduced subject distortion without resorting to external image processing,

79. apparatus according to claim 1 in which said mounting means provide for translating the overall optical system in front of a camera or similar article in order to allow a larger overall image to be photographed in two or more separate pictures on a rectangular format, facilitating a larger image scale in the resulting images,

80. apparatus according to claim 1 in which said outer refracting surface is covered with a thin layer of removable transparent material such as or similar to that used in making pellicle beam splitters, said material being in contact with said outer refracting surface of said solid optic and capable of protecting it from abrasion, erosion, or chemical influence,

81. apparatus according to claim 1 in which said outer optical surface encloses only the secondary reflector surface and does not occupy the entire area between said secondary reflector surface and said primary reflector surface, said optical surface between said reflector surfaces comprising a transparent axial strut; whereby said vantage point is in optical communication with said great circle and said area in front and behind said great circle by means of reflection from said primary reflector surface, refraction through said substrate, reflection from said secondary reflector surface, transmission down the inside of said transparent axial strut, refraction through the rear surface of said substrate, and refraction by said imaging and correcting lenses.

82. An optical system comprising:

* a solid optical substrate having a convex outer refracting surface, said surface covering most of the front and side of said substrate,

* said substrate having an internal convex reflector surface of radial symmetry,

* said reflector surface being in optical communication with a great circle surrounding it, the plane of said great circle being perpendicular to the optical axis of said reflector surface, said optical communication being through the outer refractive surface of said substrate,

* said reflector surface having sufficient curvature to be in optical communication with a substantial area in front of and behind the plane of said great circle,

* whereby said optical system produces a virtual image of said great circle and said area above and below its plane, said virtual image being annular,

* said virtual image being visible from an axial vantage point outside said substrate and in front of said reflector surface, said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said reflector surface and refraction through the surface of said substrate;

* means for mounting said substrate,

* said means for mounting having provision for handling said optical system without touching its optical surfaces;

* said means for mounting providing stable support and alignment of said substrate without causing deformation thereof,

* said means for mounting providing for attachment of said optical system to an article having a focal surface.

* said article being in front of said reflector surface,
* said mounting means facilitating use of said optical system in any orientation,
* said optical system being associated with a refracting lens system, said refracting lens system being disposed coaxial to said optical system, both being associated with the formation of a real image of said virtual image at said focal surface,

* whereby said optical system when combined with said article having a focal surface facilitate the geometric conversion of said great circle and said area in front and behind the plane of said great circle into a real annular image at the focal surface of said article and vice versa,

83. apparatus according to claim 82 where the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution being nearly perpendicular to the light path at a zone just outside the perimeter of said article and any related baffle, whereby lateral chromatic aberration at said zone is negligible, whereby lateral chromatic aberration in the virtual image from the overall system will increase as a function of off-axis distance, thereby facilitating correction of lateral chromatic aberration by means of relatively conventional correcting optics or by separating a real image into separate colors and individually scaling each color separation,

84. apparatus according to claim 82 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having an angle of incidence to the light path at a zone just outside the perimeter of said article and any related baffle, whereby a zone in front of said optical system that would otherwise be obscured by said article and any related baffle is imaged by means of being in optical communication with said reflector surface

by refraction through said zone in said substrate, thereby extending the angle of view toward the end of the invention to which said article is attached,

85. apparatus according to claim 82 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having a substantial angle of incidence to the light path at a zone just outside the perimeter of said article and any related baffle, whereby an axial point disposed a finite distance in front of said optical system is imaged by means of being in optical communication with said reflector surface by refraction through said zone in said substrate, thereby extending the angle of view all the way around the end of the invention to which said article is attached,

86. apparatus according to claim 82 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having an angle of incidence to the light path at a zone just outside and behind the perimeter of said reflector surface, whereby a zone behind of said optical system that would otherwise be beyond the limit of coverage for said reflector surface is imaged by means of being in optical communication with said reflector surface by refraction through said zone in said substrate, thereby extending the angle of view toward the end of the invention opposite said article,

87. apparatus according to claim 82 in which the outer refracting surface of said substrate comprises a surface of revolution, said surface of revolution having an angle of incidence to the light path at a zone just outside and behind the perimeter of said reflector surface, whereby an axial point a finite distance behind said optical system is imaged by means of being in optical communication with said reflector surface by refraction through said zone in said substrate, thereby extending the angle of view all the way around the end of the invention opposite said article,

88. apparatus according to claim 85 in which the outer refracting surface of said substrate has an angle of incidence to the light path at a zone just outside and behind the perimeter of said reflector surface, whereby an axial point a finite distance beyond the end of said optical system opposite said article is imaged by means of being in optical communication with said reflector surface by refraction through said zone in said substrate, thereby extending the angle of view all the way around the end of the invention opposite said article, resulting in coverage of the entire sphere around said optical system,

89. apparatus according to claim 82 in which said outer refracting surface is comprised of a plurality of scallops which are concave as seen from the front but convex as seen from the side, refraction through said scallops causing the area occupied by each scallop to have more than twice the included angle as the angular circumference of the optical surface it occupies; for example, as seen from the front, each scallop of a twelve scallop optical system would occupy 30 degrees of the circumference as seen from the front; therefore, each of said scallops would provide more than 60 degrees of coverage; said optical system providing a sectored virtual image, said image having the same number of sectors as said refracting surface has scallops, each of said scallops covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points, said points being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage; said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system also being applicable for the basis of image

processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, (not supported by the applicant's provisional applications)

90. apparatus according to claim 82 in which the figure of said outer refracting surface is optimized to minimize flare and ghost images,

91. apparatus according to claim 82 in which the outer refracting surface of said substrate has anti reflection coatings,

92. apparatus according to claim 82 in which said reflector surface has reflective coatings which facilitate efficient reflection at a wide range of incident angles, including angles not subject to total internal reflection,

93. apparatus according to claim 82 in which the perimeter of said optical system provides means for accurately indicating the limits of the image it produces,

94. apparatus according to claim 82 in which said reflector surface has reflective coatings which facilitate efficient reflection at a wide range of incident angles, including angles not subject to total internal reflection,

95. apparatus according to claim 82 in which said reflector surface comprises a surface of revolution, said surface of revolution being radially compressed inward toward the optical axis, whereby the apex of said reflector surface comprises a point, whereby said vantage point in front of said reflector surface is in optical communication with a smaller angular area in front of said great circle, thereby increasing the size of a central angular exclusion zone in front of said reflector surface while eliminating the image area occupied by said article, thereby increasing the radial proportions of the imaged area immediately surrounding the plane of said great circle, thereby resulting in a larger radial image scale for said area covered on a given image format, owing to the reduced relative size of an imaged central obscuration area,

96. apparatus according to claim 82 in which said convex reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being radially enlarged outward from the optical axis, whereby the surface of said convex reflector surface is closer to perpendicular with the optical axis at a zone which immediately surrounds the reflection of said article having a focal surface, whereby said focal surface is in optical communication with a greater angular area in front of said great circle, thereby reducing the size of the central angular exclusion zone in front of said convex reflector surface caused by said article after accounting for refraction by the outer surface of said optical system,

97. apparatus according to claim 82 in which said convex reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being torroidal as a result of being radially enlarged outward from the optical axis, whereby said torroidal reflector surface curves backward in the zone immediately surrounding an area the size of a central obstruction, whereby the radial zone of said torroidal reflector surface by which the focal surface of said article is in optical communication with an axial point disposed at a finite distance in front of said optical system by means of reflection from said zone of said torroidal reflector surface has a larger diameter than the obstruction of said article, thereby eliminating the central angular exclusion zone in front of said reflector surface, the only excluded area being confined to a narrow conical area extending from the perimeter of said article with any associated mounting and shielding to said axial point disposed a finite distance in front of said torroidal reflector surface after accounting for refraction by the outer surface of said optical system,

98. apparatus according to claim 82 in which said convex reflector surface has a scalloped surface resulting in a plurality of convex lobes disposed evenly around its circumference, each

lobe having more than twice the included angle as the angular circumference of the reflector surface it occupies; for example, as seen from the front, each lobe of an twelve lobe reflector surface would occupy 30 degrees of the circumference; therefore, each of said lobes would have more than 60 degrees of curvature as seen from the front; said scalloped reflector surface providing a sectored virtual image, said image having the same number of sectors as said scalloped reflector surface has lobes, each of said sectors covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points and being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage, said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system are also being applicable for the basis of image processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

99. apparatus according to claim 82, in which only the side of said outer refracting surface is utilized between said reflector surface and the imaged area surrounding said optical system, the front of said substrate having a large surface through which the entirety of said reflector surface can be seen from a distant axial viewpoint, said optical system facilitating use at a distance from a camera or observer, whereby the image may be observed or recorded with an optical system having magnification,

100. apparatus according to claim 99, in which said optical system is supported in front of said article having a focal surface by means of an axial strut,

101. apparatus according to claim 82 in which the entirety of said outer refracting surface is a continuous surface of revolution which is close to said reflector surface, the combination comprising a mangin mirror in which said outer refractive surface is utilized to correct for aberrations and distortion, said article having a focal surface typically being disposed a distance from the front of said outer refracting surface,

102. apparatus according to claim 82 in which said reflector surface is a hemisphere and said outer reflective surface comprises a hyperhemispherical surface which is concentric with said reflector surface, said optical system being applicable to utilization for observation or projection of an image from a remote or nearby vantage point,

103. apparatus according to claim 82, further comprising refracting lenses, said refracting lenses being coaxial with said reflector surface, said lenses correcting for curvature of the virtual image and aberrations resulting from oblique reflections off said convex reflector surface, said means for mounting positioning said refracting lenses between said reflector surface and the focal surface of said article, said means for mounting having an attachment to said substrate, said means for mounting including a cell for said refracting lenses and facilitating unobstructed optical communication between said lenses, said article, and said reflector surface, said refracting lenses being in optical communication with said great circle surrounding said reflector surface by means of reflection from said reflector surface and refraction through said outer refracting surface, and said secondary reflector, said refracting lenses having a longitudinal position corresponding to said axial vantage point which is in optical communication with said great circle and said area in front and behind the plane of said great circle, said longitudinal position of said vantage point being varied according to the embodiment and application of said optical system, as marginally supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

104. apparatus according to claim 103, further comprising a filter holder,

105. apparatus according to claim 103, further comprising a series of refracting lenses in interchangeable cells which are each capable of producing a real image from the overall optical system at a focal surface, said cells being of appropriate lengths to produce proper focus and image size at said focal surface when used with the intended article having a focal surface, said cells also incorporating adaptation and mounting means for appropriate standardized adapters and camera and instrumentation mounting interfaces,

106. apparatus according to claim 103 in which said refracting lenses are capable of producing a real annular image of the virtual image resulting from reflections off said reflector surface and refraction through said outer refracting surface, said real image being at the focal surface of said article, mounting means for said refracting lenses also providing means for aperture adjustment,

107. apparatus according to claim 103 in which said reflector surface said associated refracting optics are capable of causing all rays from the overall optical system to be parallel, enabling said optical system to be used in front of a lens for a film camera, video camera, or similar article, where said lens is focused at infinity (or hyperfocal distance in the case of a fixed focus lens).

108. apparatus according to claim 82, whereby said optical system is associated with a projector and a cylindrical projection surface to facilitate the geometric conversion of an annular image into a cylindrical projection around said optical system, whereby said convex reflector surface has a strong aspheric figure which, in conjunction with said outer refracting surface, facilitates correct image proportions and substantially constant projection brightness throughout the projection area, said cylindrical projection being applicable to display and printing,

109. apparatus according to claim 82, whereby said optical system is associated with a projector and a spherical projection surface to facilitate the geometric conversion of an annular image into a spherical projection around said optical system, whereby said convex reflector surface is at the center of said spherical projection surface, said reflector surface having an aspheric figure which, in conjunction with said outer refracting surface, facilitates correct image proportions and constant projection brightness throughout the projection area,

110. apparatus according to claim 82, whereby said optical system is associated with a projector and a spherical or semi spherical projection surface to facilitate the geometric conversion of an annular image into a spherical projection around said optical system, whereby said convex reflector surface is at a position other than the center of said spherical or semi spherical projection surface, said reflector surface having a strong aspheric figure which, in conjunction with said outer refracting surface, facilitates correct image proportions and constant projection brightness throughout the projection area in spite of the varying distances to said projection area, said apparatus being applicable to applications including virtual reality headsets, games, simulators, booths, suites, and theaters, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

111. apparatus according to claim 82, whereby said optical system is used to image, display, and simulate phenomena associated with a total solar eclipse, said optical system being associated with a projector for display of said subject matter by projection, whereby said convex reflector surface is at a position other than the center of a spherical or semi spherical projection surface, said reflector surface having a strong aspheric figure which, in conjunction with any refractive effects from said outer refracting surface, facilitates correct image proportions and constant projection brightness throughout the projection area in spite of the varying distances to said projection area, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

112. apparatus according to claim 110, in which a plurality of said optical systems are utilized to project images into multiple rooms, including multiple portal virtual reality suites and theaters; said apparatus providing for the active masking of projection onto doorways which may be opened and closed, said masking accomplished by means of masks which are positioned in order to obstruct optical communication between an open doorway and the projection source, said masking means having provision to be synchronized with the opening and closing of doors and portals between different rooms; further, a fixed mask may be used where a doorway is always open, said fixed mask being a separate part of a coating such as paint which is applied to the surface of said outer refracting surface,

113. apparatus according to claim 110, whereby two of said optical systems are associated with a projector and a spherical or semi spherical projection surface, said optical systems being off center and on opposing ends of said spherical projection area, said arrangement facilitating the geometric conversion of two annular images into a spherical projection which covers the entire inside of said spherical projection area without obstructing the center of said projection area or requiring projector light to pass through the center of said spherical projection area, thereby allowing members of an audience to be positioned at and near the center of said projection area, said reflector surface also having provision for rear projection means onto an area surrounding the back surface of its perimeter, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

114. apparatus according to claim 113, further comprising means to suspend one or more members of an audience at and near the center of said projection area, said suspension means having provision for lowering and raising an audience member to and from the floor, the surface of said projection area under the audience being comprised of inexpensive modular sections which can be replaced if soiled by a participant's feet or the results of motion sickness, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997.

115. apparatus according to claim 82, embodied in any size laparascopic surgical or observation instrument, endoscope, sigmoidoscope, bore scope, camera, projector, surveillance instrument, flight control system, robotic device, or similar article, said article incorporating means for providing illumination of the subject as appropriate,

116. apparatus according to claim 115 in which said laparascopic or other instrument article includes electronic imaging means and has means for interface to systems facilitating substantial real time digital processing of the image produced therewith,

117. apparatus according to claim 115 in which two omnidirectional optical systems are incorporated into a single instrument, said optical systems being pointed in opposite directions in order to provide redundant coverage of the entire subject with opposing image projections, resulting in reduced distortion of many parts of the subject without resorting to external image processing,

118. apparatus according to claim 115, in which two such omnidirectional optical systems are incorporated into a single instrument, one or more of said optical systems being independently positionable in order to provide redundant coverage of the entire subject with configurable image projections, resulting in reduced subject distortion without resorting to external image processing,

119. apparatus according to claim 82, in which said reflector surface and said outer refracting surface have substantially more curvature than that required for full sphere coverage in conventional surroundings, whereby full sphere coverage is achieved when said optical system is immersed in liquid,

120. apparatus according to claim 95, further comprising axial expansion optics in front of said reflector surface, said expansion optics expanding the coverage of a lasers or other light source to cover the entirety of said reflector surface, thereby providing omnidirectional expansion of said light source for applications including holographic imaging and projection,

121. apparatus according to claim 82 in which said convex reflector surface comprises a surface of revolution, said surface of revolution having a prolate aspheric figure.

122. apparatus according to claim 82 in which said substrate surrounds a hyperhemispherical refracting optical system such as a fisheye lens, said substrate acting entirely as a refracting element and extending the field of view of an said hyperhemispherical fisheye lens, the internal surface of said substrate having a hyperhemispherical void rather than a reflecting surface, said fisheye lens being axially positioned inside of said substrate, the perimeter of the front element of said fisheye lens being just in front of the rear limit of said internal hyperhemispherical surface of said substrate.

123. An optical system comprising:

* a convex specular reflector having radial symmetry,
    * said reflector being in optical communication with a great circle surrounding it, the plane of said great circle being perpendicular to the optical axis of said reflector
    * said reflector having sufficient curvature to be in optical communication with a substantial area in front and behind the plane of said great circle,
* said reflector being surrounded by an annular optical element having a radial cross section similar that of the front element of a fisheye lens,
    * said annular optical element extending the field of view of said reflector to cover a greater angle in front and behind the plane of said great circle,
* whereby said optical system produces a virtual image of the said great circle and said area above and below its plane, said virtual image being annular,

* said virtual image being visible from a vantage point in front of said reflector by means of said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said convex reflector and refraction through said annular optical element,

* means for mounting and said optical system,
    * said means for mounting providing stable support and alignment of said reflector and annular optical element without causing deformation thereof,
    * said means for mounting providing for attachment of said optical system to an article having a focal surface,
    * said article being in front of said reflector,
    * said means providing a shielding to preventing stray light from entering,
    * said mounting means facilitating unobstructed optical communication between said article and the utilized radial zones of said convex reflector,
    * said optical system being associated with a refracting lens system, said refracting lens system being disposed coaxial to said optical system, both being associated with the formation of a real image of said virtual image at said focal surface,

* whereby said optical system combined with said article facilitate the geometric conversion of said great circle and said area in front and behind the plane of said great circle into a real annular image at the focal surface of said article and vice versa, (not supported in the applicant's provisional applications; conceived in claimed form on the evening of Friday, 27 March, 1998)

124. apparatus according to claim 123 in which said annular optical element extends the field of view from each side of said reflector to more than 180 degrees, whereby said optical system covers the entire sphere around itself while having a lighter weight than the other embodiments of the present invention, said optical being produced by turning or other means,

125. apparatus according to claim 123 in which the effective radius of said reflector increases toward the central and edge zones, whereby reflection from said reflector compensates for radial compression of the image caused near the limits of coverage for said annular lens, where the cross section of said annular lens is of an embodiment having semi circular curves,

126. apparatus according to claim 123 in which the figure of said reflector is radially compressed, the apex of said reflector being a point, whereby a visible reflection of the area occupied by said article having a focal surface is excluded from the field of view, thereby providing a larger radial image scale for the image produced by said optical system on a given format, whereby said reflector when made of sufficient radial compression will enable a circular image at said focal surface as opposed to an annular one,

127. apparatus according to claim 123 in which the figure of said reflector conical,

128. apparatus according to claim 123 in which the figure of said reflector is like that of a convex cone having a concave curvature on its sides, whereby said figure causes radial distribution of the image to be the reverse of that produced by reflection from a conventional convex reflector, (Remarks: A side view of this reflector would be reminiscent of a side view of a "chocolate drop" candy.)

129. apparatus according to claim 123 in which the figure of said reflector is configured to cause the virtual center of all utilized reflections from it to be at the same axial point, thereby optimizing it to minimize distortion of the entrance pupil for the overall optical system,

130. apparatus according to claim 123 in which said reflector consists a solid catadioptric substrate having an internal reflector surface, the outside surface thereof being utilized to reduce

distortion and aberrations,

131. apparatus according to claim 123, also having imaging and correcting optics between said reflector and said focal surface;

132. apparatus according to claim 131, in which one or more elements in said imaging and correcting optics has an annular deviation in its figure (similar in concept to a Schmidt corrector but more pronounced) which is utilized in correcting aberrations from said annular lens, said aberrations including bidirectional lateral chromatic aberration and astigmatism, said reflector having a figure which is used in the control of astigmatism and correction for spatial distortion in the annular image caused by said annular figure of said imaging and correcting optical element;

133. apparatus according to claim 131, in which said means for mounting includes an axial cell for said imaging optics, said means for mounting also providing attachment means for devices including as a solar occulting object, a level indicator, and data display devices; said level indicator being internal or external, said means for mounting also providing attachment means for a camera, projector, or similar article,

134. apparatus according to claim 123 in which said annular lens is longitudinally asymmetrical in order to compensate for attributes of said reflector, where the virtual center of utilized reflections from various zones of said reflector varies according to each zone utilized,

135. apparatus according to claim 123 in which said reflector is the primary reflector of a Cassegrain system, said primary reflector having a hole in its center, said optical system having a secondary reflector and said article having a focal surface being behind said primary reflector,

136. apparatus according to claim 123 in which said annular lens is scalloped in order to provide redundant coverage, said redundant coverage providing three dimensional information,

137. apparatus according to claim 123 in which the longitudinal position said reflector is such that the central apex of said reflector is at a longitudinal position having proximity to the longitudinal center of said annular (or semi torroidal) optical element.

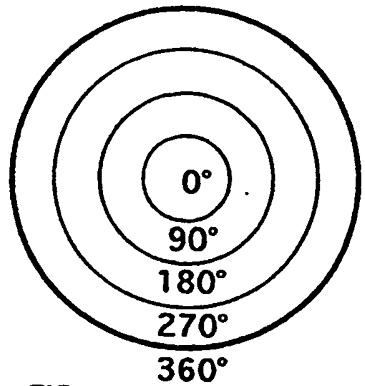



FIG. 1
CIRCULAR COVERAGE

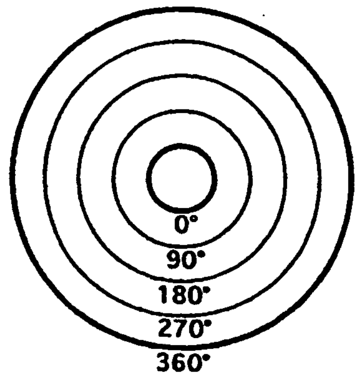



FIG. 2
ANNULAR IMAGE

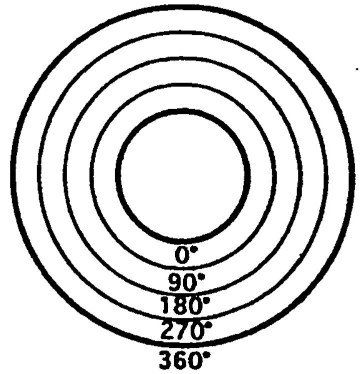



FIG. 3
ANNULAR IMAGE FROM
TORROIDAL REFLECTOR

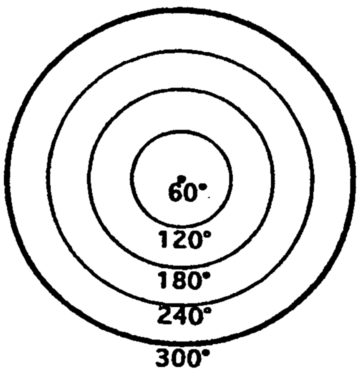



FIG. 4
CIRCULAR IMAGE FROM
REFLECTOR HAVING
POINTED APEX

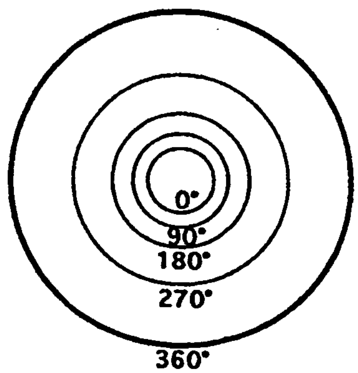



FIG. 5
RADIALLY INCREASING
IMAGE SCALE FOR OFF-
CENTER PROJECTOR

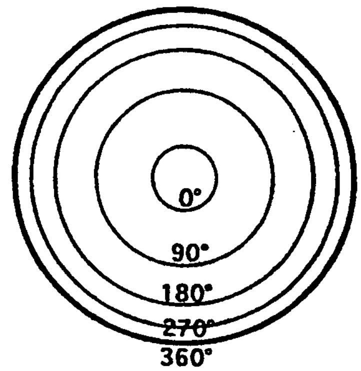



FIG. 6
RADIALLY DECREASING
IMAGE SCALE FOR OFF-
CENTER PROJECTOR

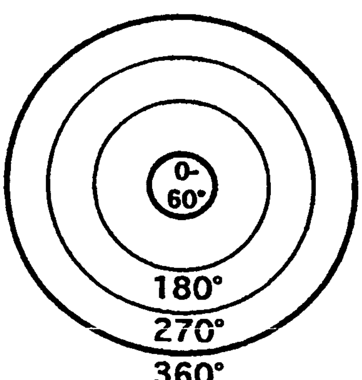



FIG. 7
CIRCULAR COVERAGE
WITH MERGED COVERAGE
FROM CENTRAL LENS

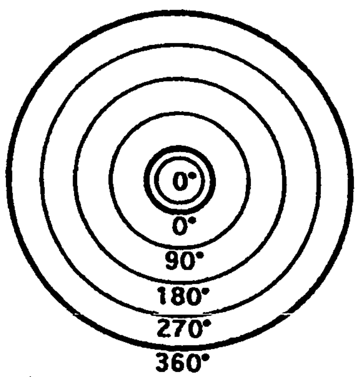



FIG. 8
REDUNDANT CENTRAL
COVERAGE

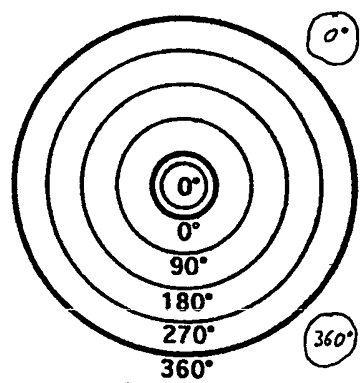



FIG. 9
REDUNDANT CENTRAL
AND REAR COVERAGE
WITH AUXILIARY OPTICS

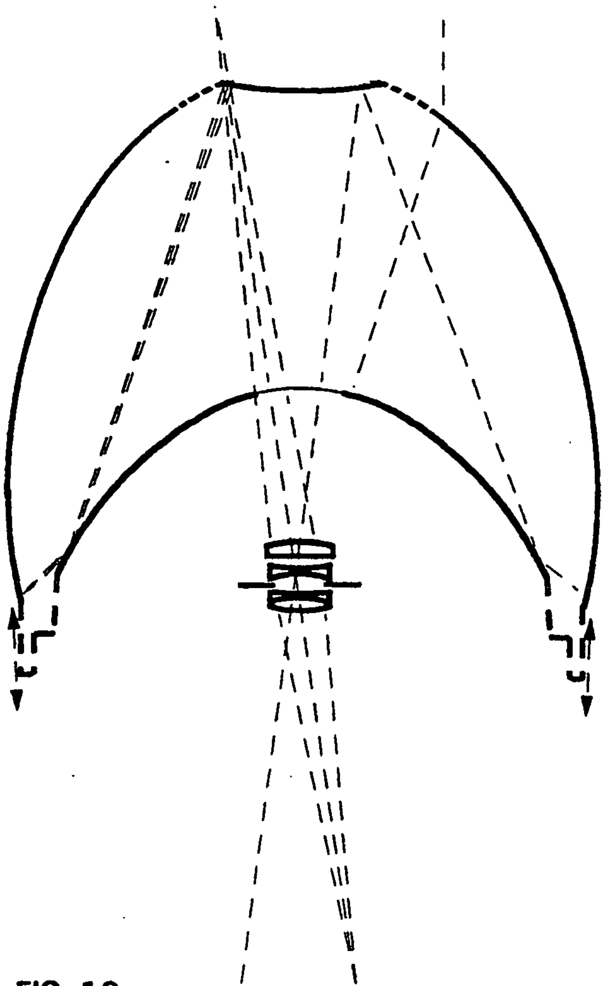


FIG. 10
OMNIDIRECTIONAL EMBODIMENT PRODUCING AN ANNULAR IMAGE

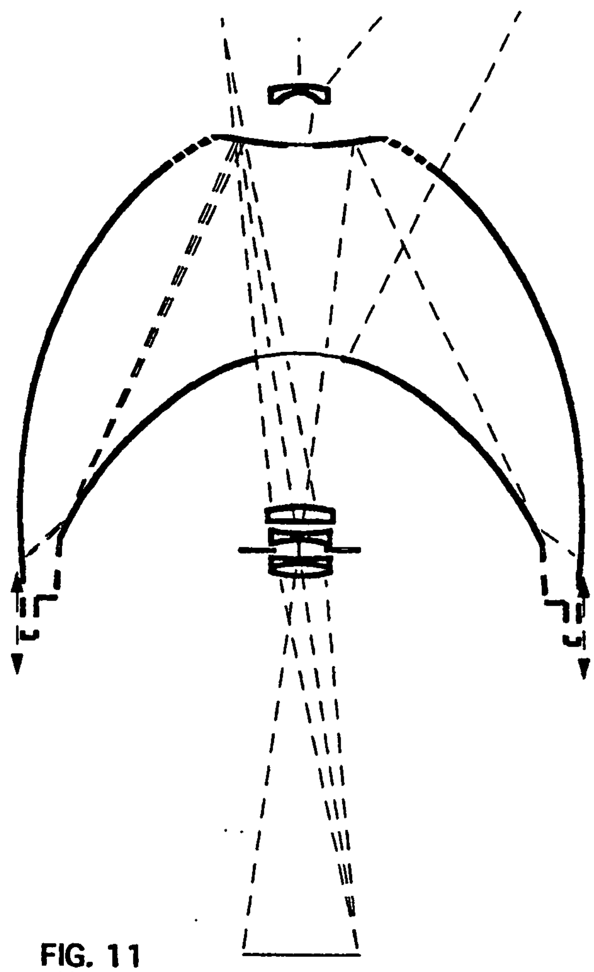


FIG. 11
OMNIDIRECTIONAL EMBODIMENT HAVING CENTRAL OPTICS, PRODUCING A CIRCULAR IMAGE WITHIN AN ANNULAR IMAGE

Tripod, etc. attachment means on back

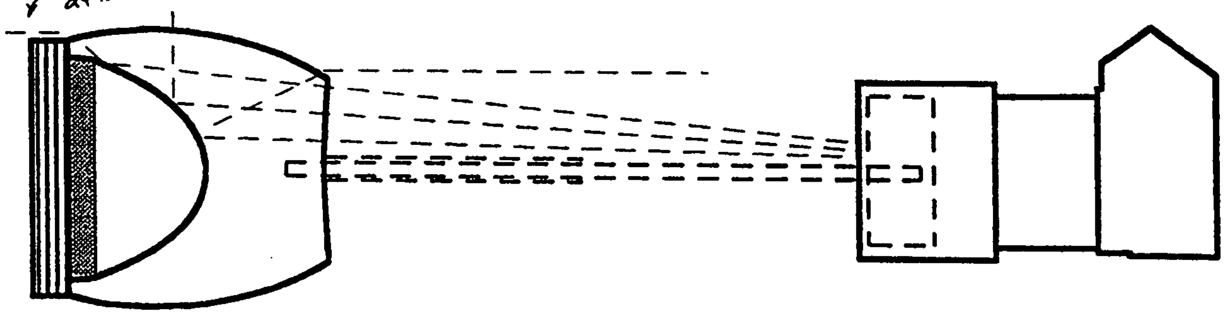


FIG. 12 Strut of arbitrary length shown.
REMOTE OMNIDIRECTIONAL RETROREFLECTING EMBODIMENT WHICH CAN BE PHYSICALLY SEPARATE FROM A CAMERA, PROJECTOR, TELESCOPE, OR SIMILAR ARTICLE. THICK DASHED LINES SHOW AN AXIAL STRUT WHICH WOULD BE UTILIZED IF OPTIC ATTACHED.

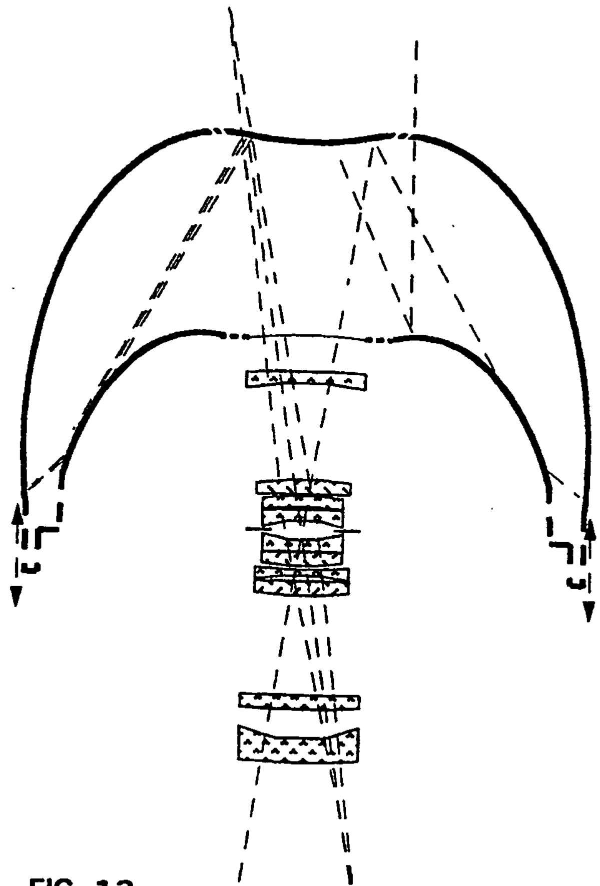


FIG. 13
OMNIDIRECTIONAL EMBODIMENT HAVING A TORROIDAL PRIMARY REFLECTOR SURFACE, SYSTEM PRODUCING AN ANNULAR IMAGE

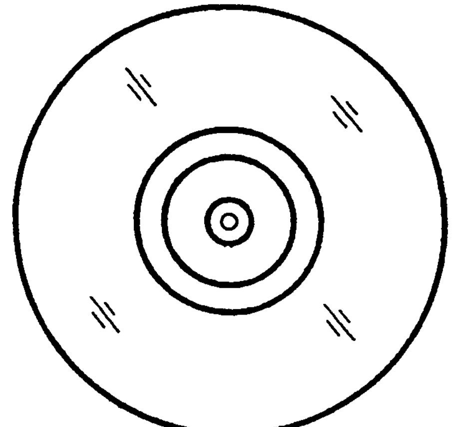


FIG. 14
FRONT VIEW

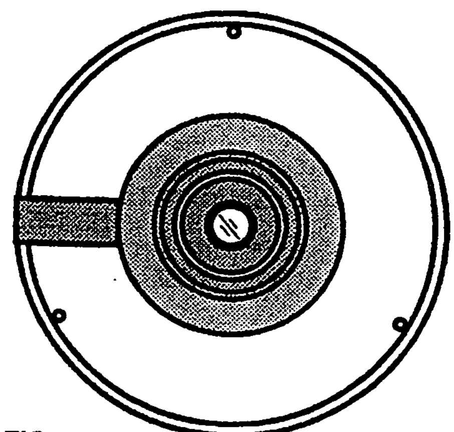


FIG. 15
REAR VIEW

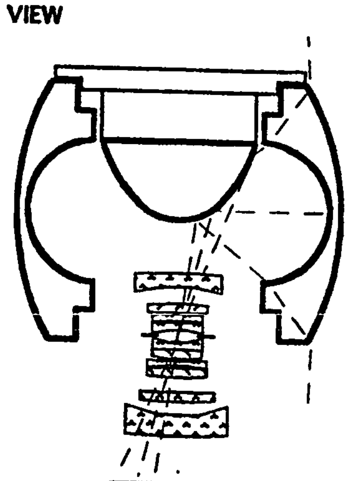


FIG. 16
OMNIDIRECTIONAL EMBODIMENT CONSISTING PRIMARILY OF A REFLECTOR WHICH IS SURROUNDED BY ANNULAR (OR TORROIDAL, DEPENDING ON DEFINITION) REFRACTING LENS, SAID LENS HAVING A RADIAL CROSS SECTION SIMILAR TO THE FRONT ELEMENT OF A FISHEYE LENS.

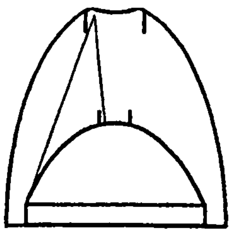


FIG. 17
BLACKENED ANNULAR BORES FOR LIGHT BAFFLE

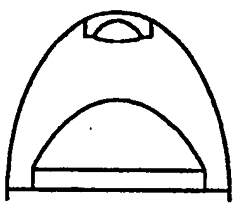


FIG. 18
SEALED FRONT CENTRAL LENS

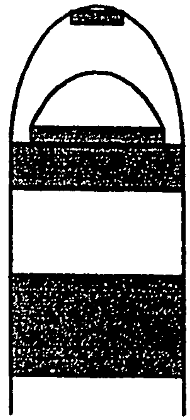


FIG. 19
MINIATURE EMBODIMENT WITH SIDE LIGHT

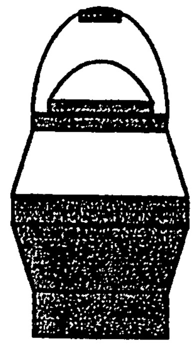


FIG. 20
MINIATURE EMBODIMENT WITH TAPERED SIDE LIGHT

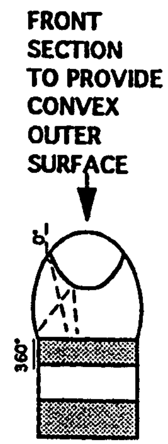



FIG. 21
RETRO-REFLECTING EMBODIMENT

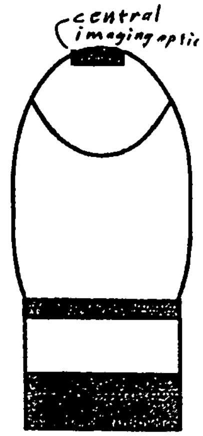



FIG. 22
RETRO-REFLECTING IMMERSION EMBODIMENT with opt. central imaging optics.

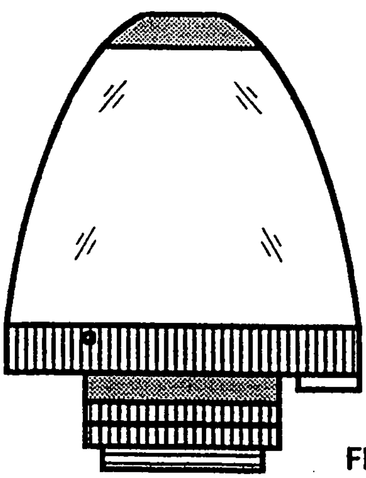


FIG. 23
EXTERIOR VIEW OF 340 DEGREE EMBODIMENT

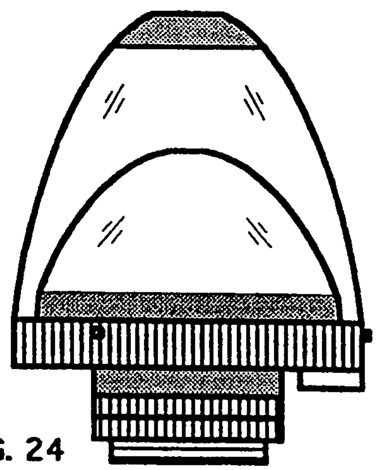


FIG. 24
340 DEGREE EMBODIMENT HAVING CONCAVE CLEAR FRONT CENTRAL SPOT.

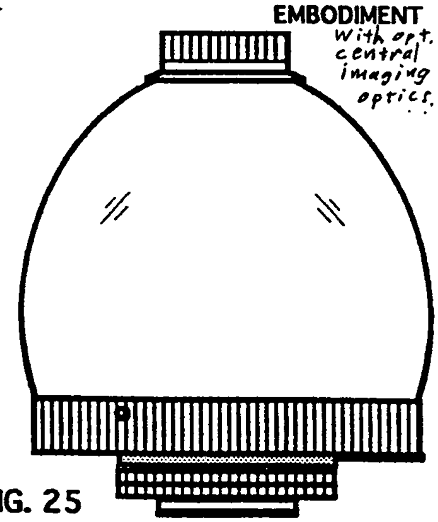


FIG. 25
EXTERIOR OF EMBODIMENT HAVING LONGITUDINALLY ADJUSTABLE FRONT CENTRAL REFRACTING OPTICS.

A matrix of suites can be used for a large number of combinations.

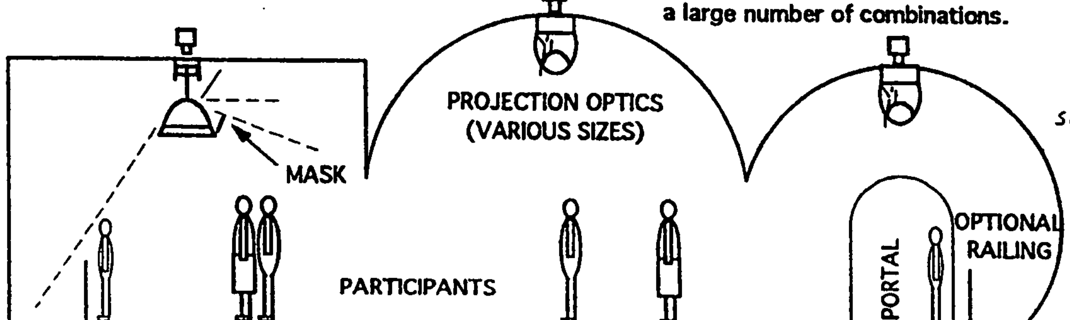



FIG. 26 VIRTUAL REALITY PROJECTION SUITE

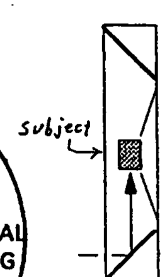



FIG. 27
PANORAMIC MICROSCOPE

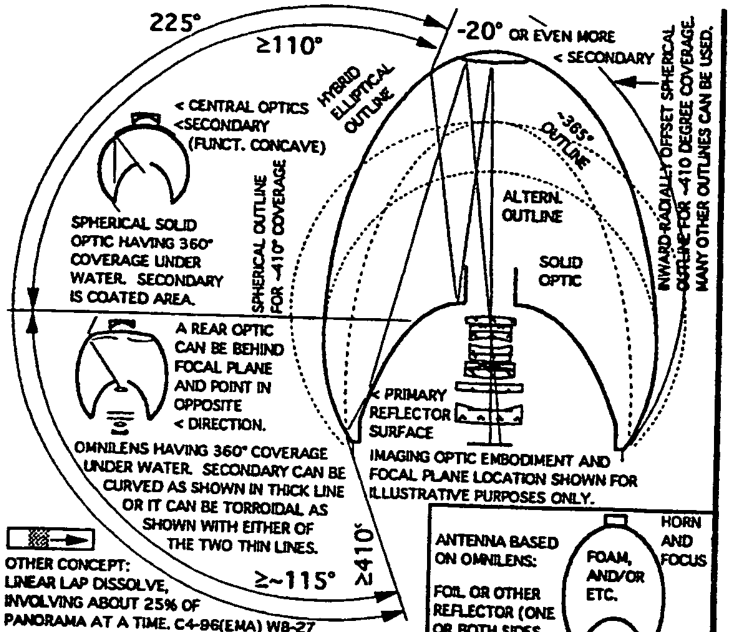



FIG. 28
VERSION OF OMNILENS HAVING SUBSTANTIAL OVERLAP. (CAN HAVE CONVENTIONAL, RADIALLY OFFSET, (INWARD OR OUTWARD) OR TORROIDAL REFLECTOR. APPLICABLE TO OMNIDIRECTIONAL UNDER WATER IMAGING.

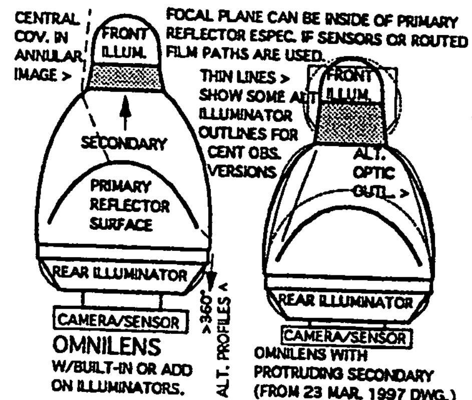



FIG. 29
ILLUMINATION MEANS FOR OMNI-DIRECTIONAL OPTICAL SYSTEM

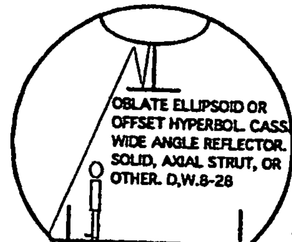



FIG. 30

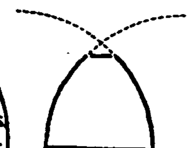


FIG. 31
ILLUSTRATION OF RADIALLY COMPRESSED OPTIC FIGURE

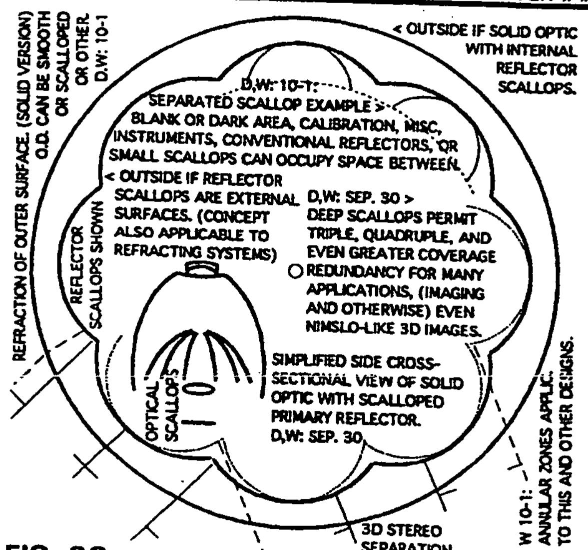
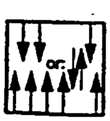



FIG. 32
SCALLOPED SOLID OR EXTERNAL OPTICAL SYSTEM FOR 3D OMNIDIRECTIONAL IMAGING, PROJECTION (SOLID SHOWN)

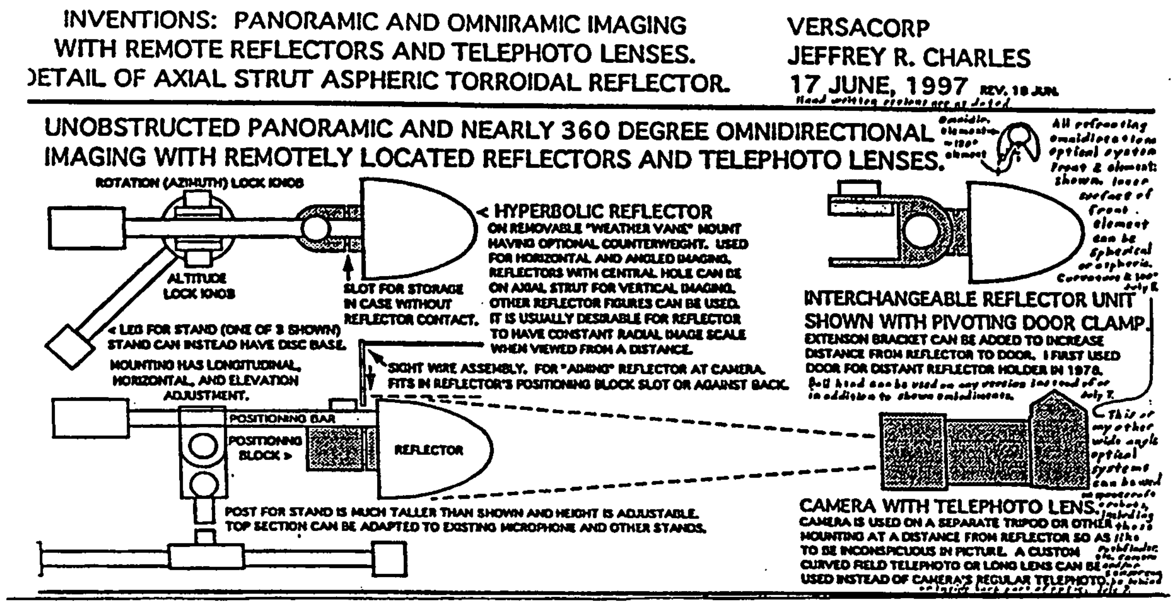


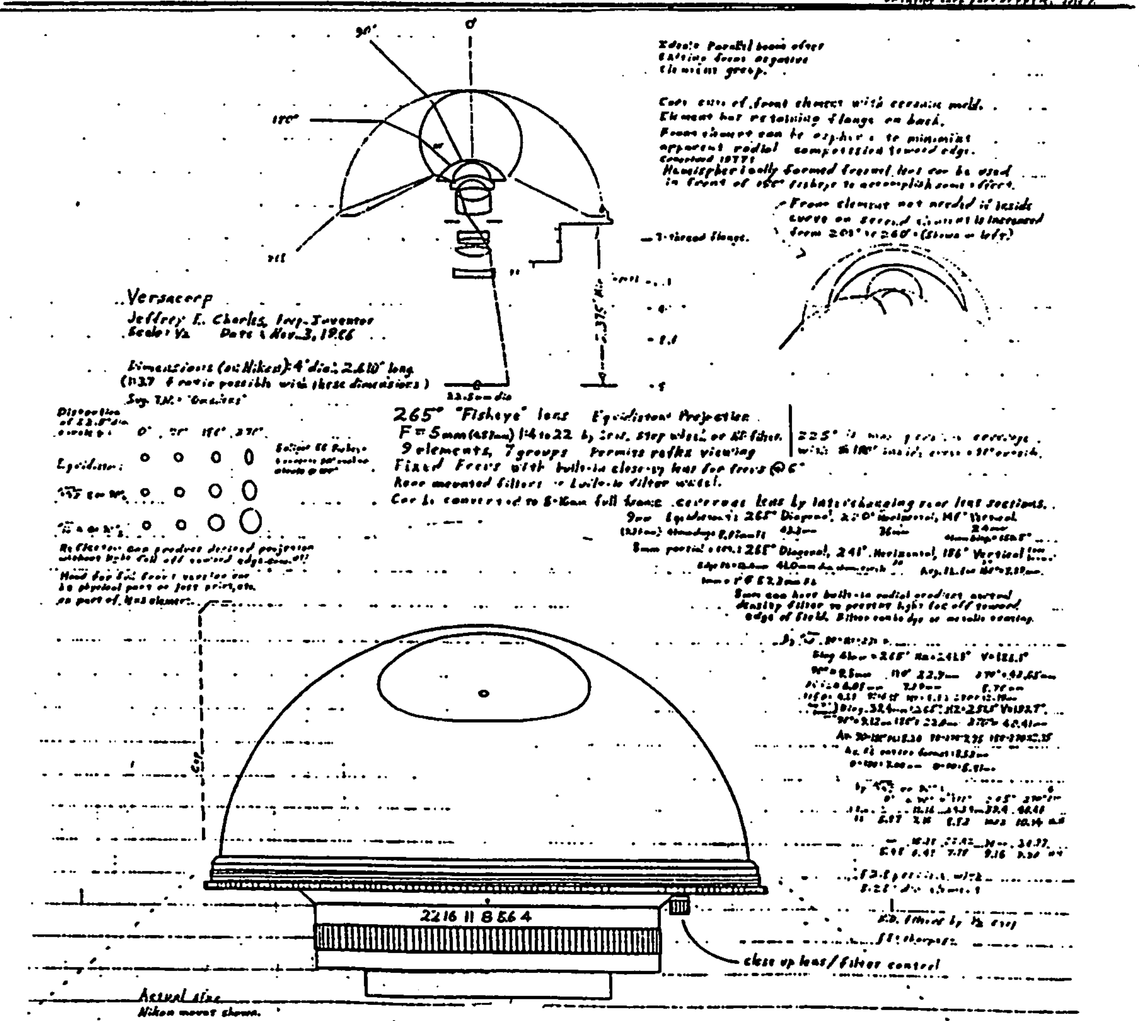

INTERLACED LAP DISSOLVE FOR HIGH RESOLUTION (~4K X 4K) DISPLAY DEVICE. FULL MOTION DISPLAY USED WHEN AVAILABLE. D8-26

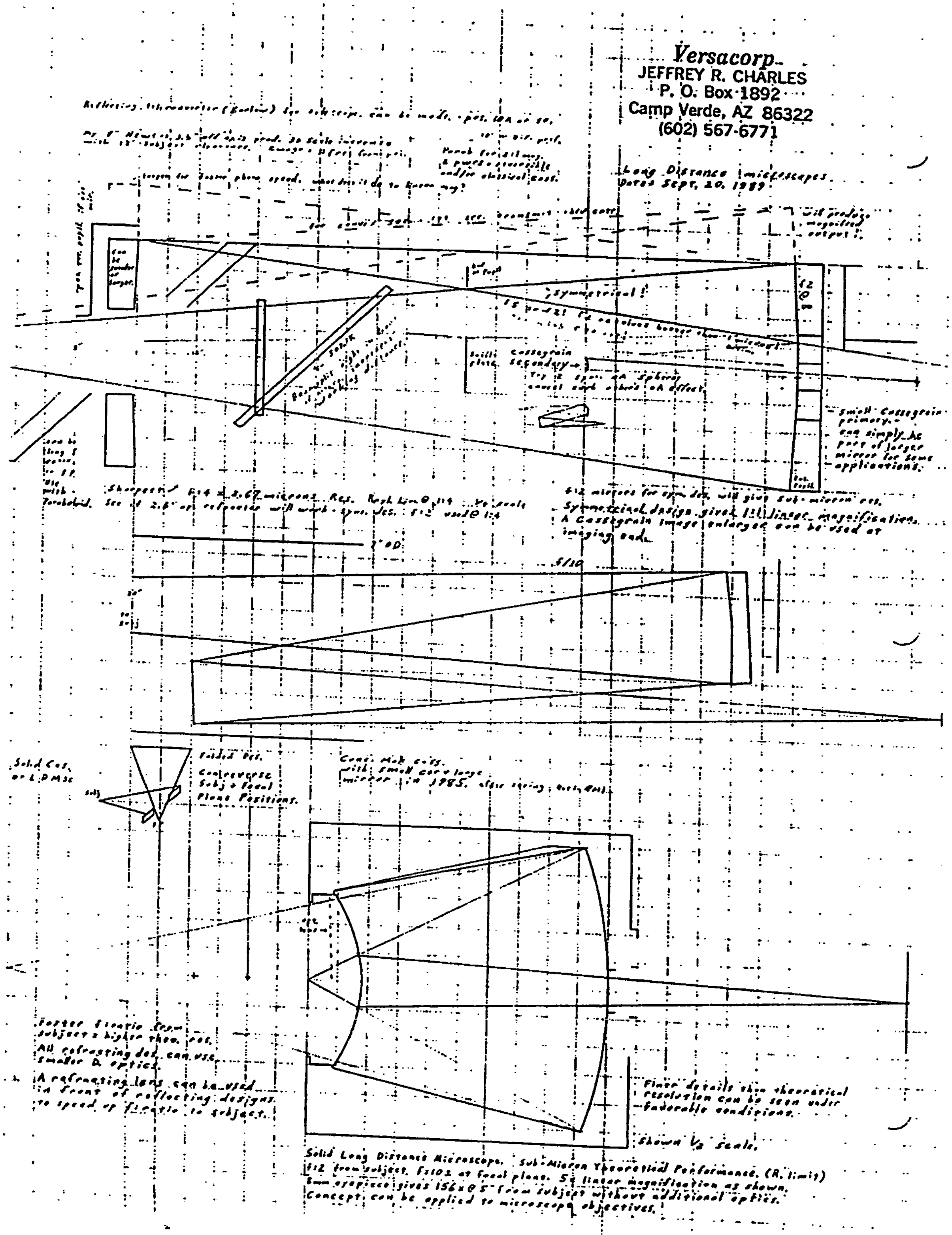
- * MORE OPTICAL SCALLOPS RESULT IN LESS VARIATION IN 3D SEP.
- * SPACES BETWEEN SCALLOPS CAN FACILITATE EVEN GREATER REDUNDANCY OF COVERAGE WITH A GIVEN NUMBER OF SCALLOPS.
- * CONCEPT CAN GO BEYOND SCALLOPS TO TRIANGULAR, SQUARE, ETC., LENS OR REFLECTOR ARRAYS FOR EVEN MORE REDUNDANCY AND MORE VANTAGE POINTS IN MORE AXES. IMAGINE PROCESSING ALGORITHMS CAN EFFICIENTLY CONFIGURE AND.OR COMBINE DATA AND/OR IMAGES.
- * APPLICABLE TO DIRECT IMAGING, CASSEGRAIN, COMPOUND, ETC.
- * APPLICABLE TO CASSEGRAIN AND/OR CONCENTRIC SYSTEMS, WHERE ONE OR MORE REFLECTORS CAN BE SCALLOPED, DEPENDING ON NUMBER OF 3D IMAGING/RANGING AXES REQUIRED. CAN BE A SOLID OPTIC (LIKE OMNILENS) WITH INTERNAL REFLECTIVE OR OTHER SCALLOPS AND/OR AN EXTERNAL REFLECTIVE SYSTEM. APPLIC. TO NEARLY ANY OVERALL OPTICAL DESIGN: AXIAL OR SIDE STRUT, OMNILENS, 3D OMNILENS, ETC.
- * CAN BE MADE OF GLASS, METAL, ETC. PLASTIC IS BEST FOR ECONOMY.
- * SCALLOPED OPTICS CAN BE USED FOR CONVENTIONAL, 3D AND 4+D (I.E. 4+AXIS) IMAGING OF SUBJECTS SURROUNDING THE OPTIC AND/OR OR SUBJECTS INSIDE THE OPTIC. (ALL VERSIONS ALSO AP. TO ANTENNAS)
- * CENTRAL IMAGING OPTICS (AND/OR ANNULAR REFLECTORS AND OTHER OPTICS OF VARIOUS SIZES RELATIVE TO THE PRIMARY REFLECTOR) CAN BE USED TO OBTAIN EXTENDED CONVENTIONAL AND/OR 3D+ COVERAGE.
- * EXTERNAL REFLECTORS AND/OR OTHER OPTICS (SCALLOPED AND OTHERWISE) CAN IMAGE EXTERNAL SUBJECTS, INWARD FACING REFLECTORS AND/OR OTHER OPTICS IMAGE INTERNAL SUBJECTS.
- * INTERNAL REFLECTORS AND/OR OTHER OPTICS (INCLUDING ANNULAR) CAN BE USED CLOSER TO OPTICAL AXIS TO IMAGE PARTS OF AN INTERNAL SUBJECT NOT NECESSARILY COVERED BY SURROUNDING SCALLOPED OR OTHER REFLECTOR FOR CONVENTIONAL OR 3D (OR EVEN 4+ AXIS) IMAGING AND/OR CHARACTERIZATION OF THE ENTIRE SURFACE (AND/OR INTERNAL STRUCTURE IN APPROPRIATE WAVELENGTHS) OF AN INTERNAL SUBJECT. SCALLOPED OR OTHER OPTIC CAN INSTEAD EXTEND ALL THE WAY (OR ALMOST ALL THE WAY) AROUND SUBJECT TO ACCOMPLISH SAME THING.

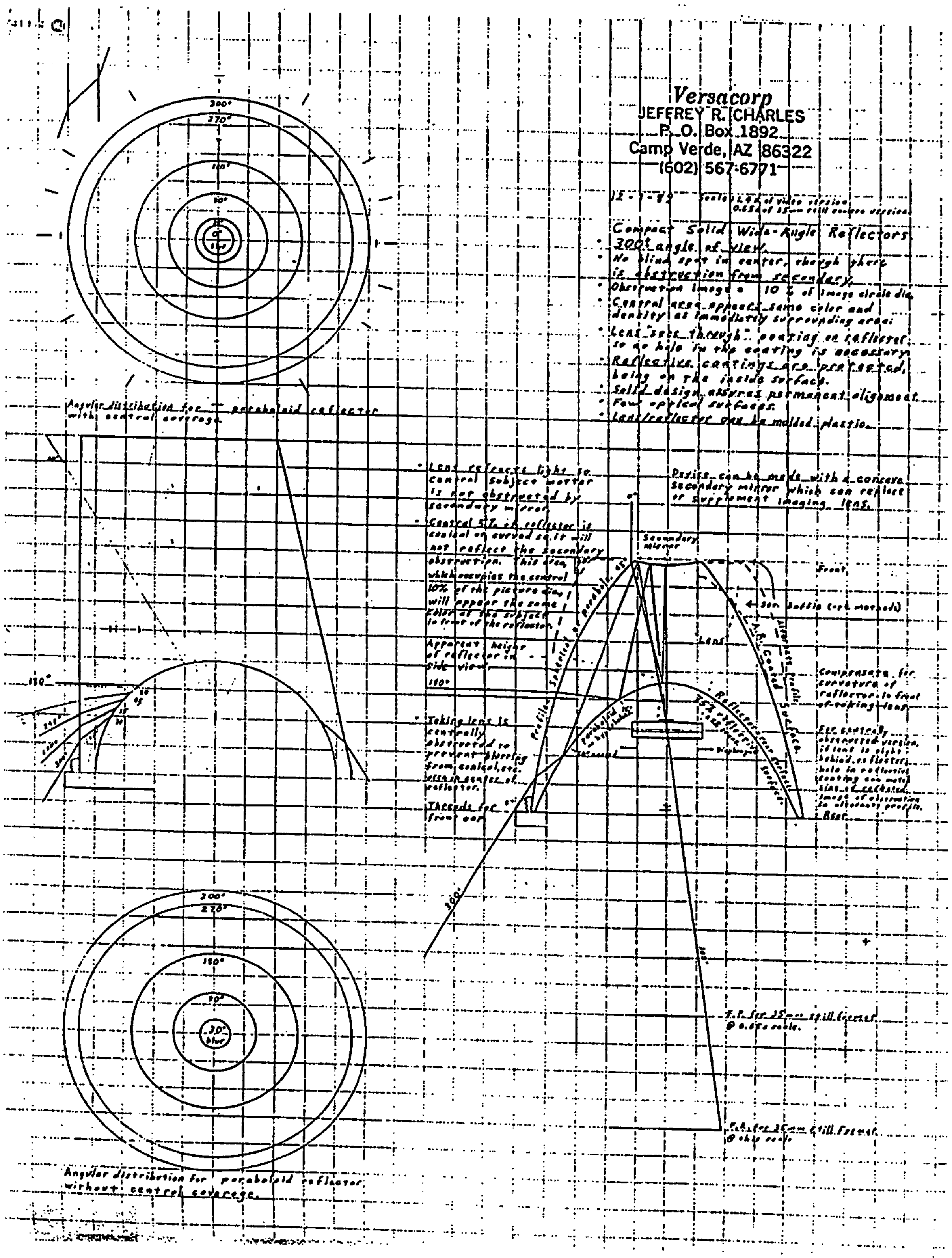
METHODS FOR INDICATING EDGE AND/OR CENTER OF HYPERWIDE IMAGE

- * PAINT, OTHER MATERIAL, OR CELL AROUND OUTSIDE EDGE
- * CROSS HAIR(S); RETICLE; FIDUCIAL; LEVEL INDICATOR, ETC., LOCATIONS
- * HOLE OR PAINT SPOT (VAR. COLORS) OR RING AROUND CENTER (INCL O.D.)
- * COLOR CALIB. BARS AND/OR OTHER STANDARDS CAN BE INCORPORATED


INVENTIONS: PANORAMIC AND OMNIRAMIC IMAGING
WITH REMOTE REFLECTORS AND TELEPHOTO LENSES.
DETAIL OF AXIAL STRUT ASPHERIC TORROIDAL REFLECTOR.
VERSACORP
JEFFREY R. CHARLES
17 JUNE, 1997
UNOBSTRUCTED PANORAMIC AND NEARLY 360 DEGREE OMNIDIRECTIONAL
IMAGING WITH REMOTELY LOCATED REFLECTORS AND TELEPHOTO LENSES.
ROTATION (AZIMUTH) LOCK KNOB
HYPERBOLIC REFLECTOR
ALTITUDE LOCK KNOB
SLOT FOR STORAGE IN CASE WITHOUT REFLECTOR CONTACT.
INTERCHANGEABLE REFLECTOR UNIT SHOWN WITH PIVOTING DOOR CLAMP.
POSITIONING BAR
POSITIONING BLOCK
REFLECTOR
CAMERA WITH TELEPHOTO LENS.
POST FOR STAND IS MUCH TALLER THAN SHOWN AND HEIGHT IS ADJUSTABLE.
TOP SECTION CAN BE ADAPTED TO EXISTING MICROPHONE AND OTHER STANDS.


Versacorp
265° "Fisheye" lens
Actual size


Versacorp
JEFFREY R. CHARLES
P. O. Box 1892
Camp Verde, AZ 86322
(602) 567-6771
Long Distance microscopes.
Dated Sept. 20, 1989
Symmetrical!
Cassegrain secondary
Small Cassegrain primary
Symmetrical design gives 1:1 linear magnification.
f/10
Folded Des.
Shown 1/2 scale.
Solid Long Distance Microscope.
Concept can be applied to microscope objectives.


Versacorp
JEFFREY R. CHARLES
P. O. Box 1892
Camp Verde, AZ 86322
(602) 567-6771
Compact Solid Wide-Angle Reflectors
300° angle of view
Angular distribution for paraboloid reflector without central coverage.
300°
270°
180°
90°
30° blur

**Proprietary wide angle presentation and image processing techniques.**
(Unpublished excerpts from my paper: "Converting a Panorama to a Circular Image and Vice Versa - Without a Computer!)

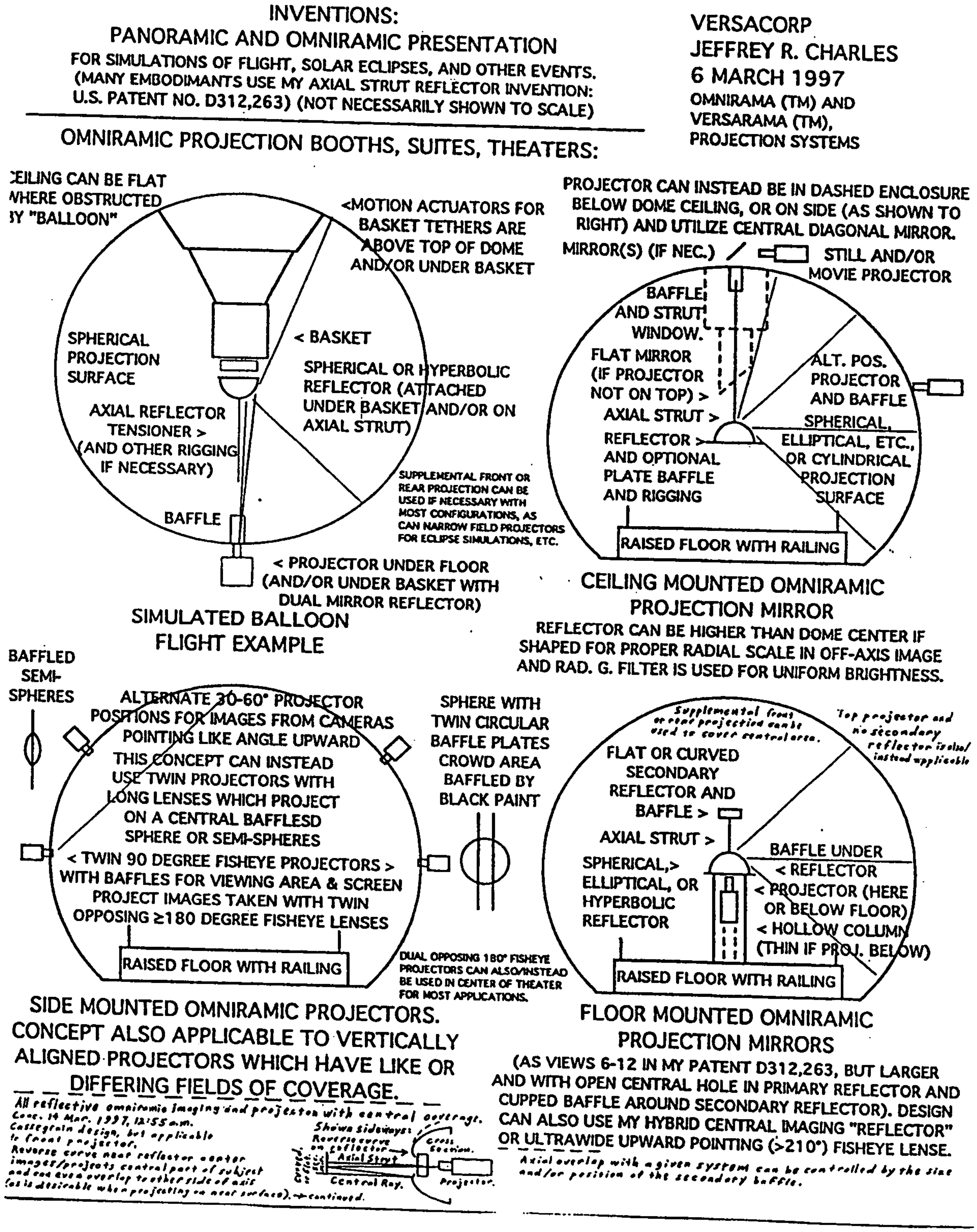

**Panoramic presentation by projection:** My patented axial strut reflectors can be used with digital, video, motion picture, 35 mm, and medium to large format cameras. Some of these, and other larger versions can be used for projecting 360 degree panoramic images in cylindrical or spherical booths, suites, or theaters. Some of my designs for panoramic projection utilize an axial strut wide angle reflector similar to the one I made in 1977, only larger. If the curved "projector reflector" is oriented the same way the reflector was when the picture was taken, it will facilitate accurate projection of the image in a spherical theater. This implies that the reflector should be pointed up for most applications, though a downward pointing one may be good for applications such as amusement park "rides" which, for example, simulate a balloon flight. When projection of the panoramic image is the primary form of presentation, an additional advantage stems from in the fact that the reflector tends to counteract its own distortion when used for projection. This can make it practical to utilize relatively inexpensive spherical reflectors for both imaging and projection. Front or rear supplemental projection or supplemental central optical systems similar to those in the improvements for my solid reflector can be used to facilitate uninterrupted projection coverage.

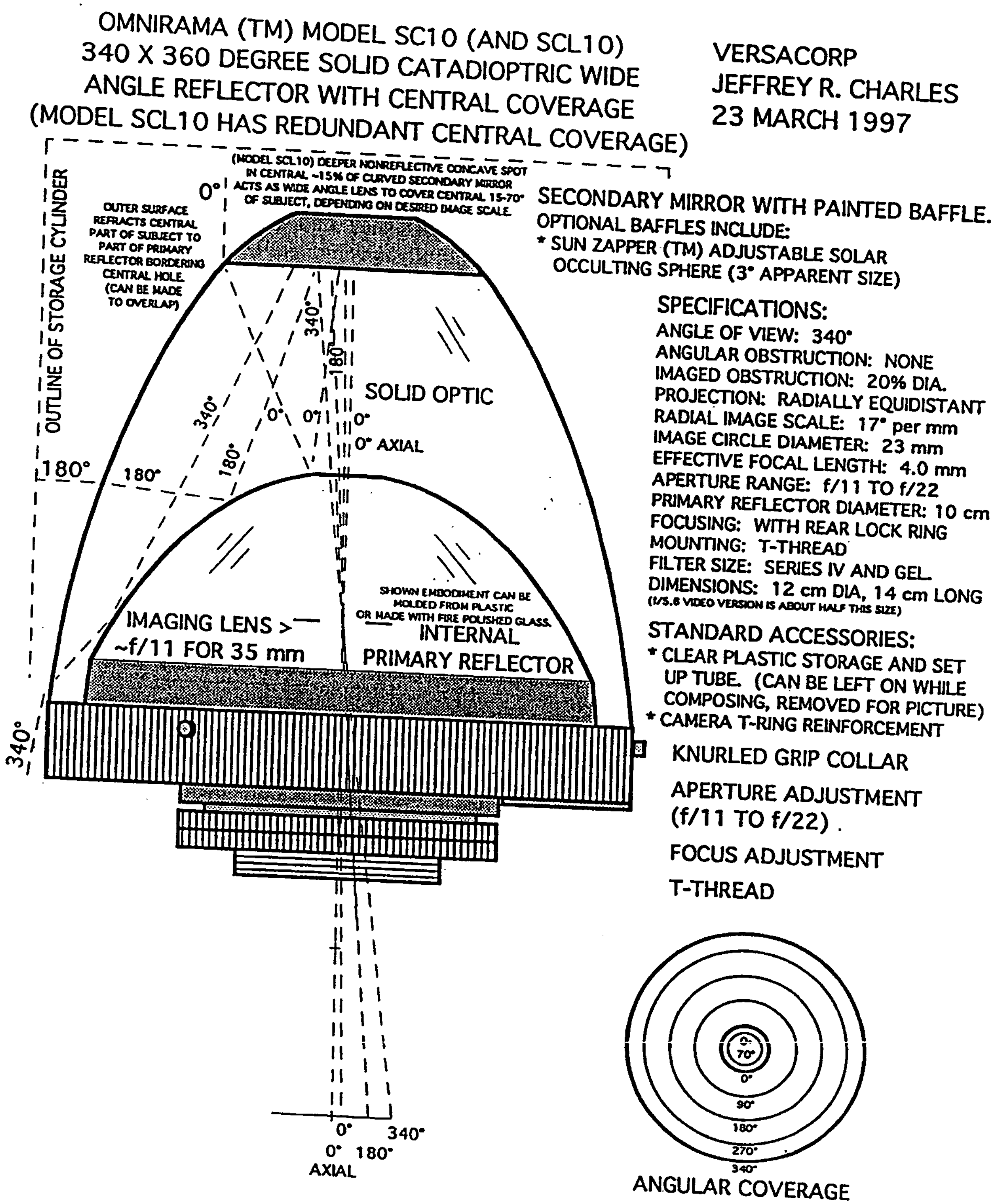
Depending on how or whether the original image is processed, the patented reflector system can be used in many configurations, either with its secondary mirror when on on a column above the floor; or, without its secondary mirror (but with its axial strut) when on a column which extends below the theater ceiling. The actual projector can either be above or below the reflector, or it can be off to the side, with its image being reflected to the wide angle reflector with a diagonal mirror. This facilitates the use of conventional motion picture projection mechanisms. This "projector reflector" gives a true surround experience because of the extraordinarily wide vertical coverage. These projection designs were initially conceived for still photos, but after I saw my first total solar eclipse in 1979, I realized its potential for full motion panoramic movies of such an event. Omnimax, (once it arrived on the market) was very good, but this reflector projection system would be even better, particularly if shown in a smaller projection suite where the participants would be free to get up and walk around - just like they would at a real eclipse or other event. Any interested customers or investors out there? Techniques also applicable to printing images. Other inventions = cylindrical, conical, or spherical, etc., panoramic lamp shades and surround print booths.

**Panoramic presentation in small viewers:** Viewing the high resolution circular panorama I had made (in 1976) under a magnifier was reminiscent of actually being at the place where I had taken the original pictures. I soon envisioned a small viewer about the size of a Viewmaster (R) that could be used to view sections of small circular panoramic transparencies or prints. I realized that it was even possible make a viewer which would optically refract or reflect the viewed area in such a way that the horizon would appear straight. I later conceived a stereo version which would use horizontal or converted circular stereo panoramas that had been taken with a rotating stereo panoramic camera.

**Digital panoramic image processing and presentation:** Software routines can be used in conjunction with popular image processing software to essentially automate the process of converting or otherwise modifying panoramas. In addition, digital processing analogous to my printing techniques could be used to actively correct and view localized areas of circular panoramas, thereby eliminating the need to convert the entire image. This would be useful in VR applications (such as my total solar eclipse panoramas) where "looking" up toward the zenith is desirable.

**Other proprietary aspects of my wide angle and panoramic inventions:**
Improvements to the solid catadioptric wide angle reflector which I drew and described in my 1 December 1989 priority document: The original invention's catadioptric element has two reflector surfaces with solid refractive material in between. The functional surfaces of the reflectors are convex. The present improvement (written 4 March, 1997, but conceived earlier) is called a "Wide angle catadioptric reflector with auxiliary axial imaging means". It is essentially the same design, but with a transparent spot in the center of the secondary reflector surface. Affixed in front of the transparent spot is an accurately positioned negative lens which provides a virtual central image having the same apparent virtual image scale and longitudinal virtual image surface location as the surrounding virtual reflected image of the virtual surface of primary reflector surface, as seen from the vantage point of the camera. The virtual image of this lens "fills in" the area obscured by the central transparent hole in the primary reflector and/or the reflection of the secondary reflector and its related baffles, thereby providing an uninterrupted picture. The slightly out of focus (and physically feathered if necessary) edge of the reflective coating bordering the transparent areas on the primary and secondary reflectors provide a smooth transition between the images from both the axial refractive and surrounding reflective optics. This design allows both reflector surfaces to be unmodified curves, even across their centers. The central lens can be in an adjustable cell or, if its rear surface is made to match the curvature of the secondary reflector surface, it can simply be accurately cemented. Other independently claimed improvements or modifications include cementing an appropriately curved lens to the rear of the primary reflector surface (and/or the front of that in the secondary reflector surface) which either cancels out the refractive qualities of the transparent surface(s) or enhances the desired virtual or real imaging characteristics of lenses external to the solid catadioptric reflector element. The original invention and these improvements are applicable to both imaging and projection. A different concept (conceived early February of 1997) involves an off-axis auxiliary optical system which images the central area outside of the wide angle image circle.

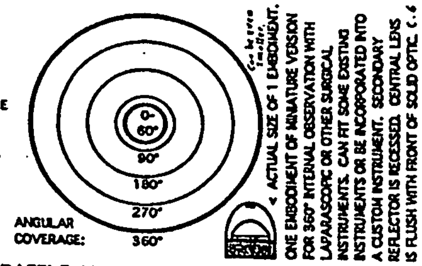

INVENTIONS:
PANORAMIC AND OMNIRAMIC PRESENTATION
FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS.
(MANY EMBODIMANTS USE MY AXIAL STRUT REFLECTOR INVENTION:
U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)
VERSACORP
JEFFREY R. CHARLES
6 MARCH 1997
OMNIRAMA (TM) AND
VERSARAMA (TM),
PROJECTION SYSTEMS
OMNIRAMIC PROJECTION BOOTHS, SUITES, THEATERS:
CEILING CAN BE FLAT WHERE OBSTRUCTED BY "BALLOON"
<MOTION ACTUATORS FOR BASKET TETHERS ARE ABOVE TOP OF DOME AND/OR UNDER BASKET
SPHERICAL PROJECTION SURFACE
< BASKET
SPHERICAL OR HYPERBOLIC REFLECTOR (ATTACHED UNDER BASKET AND/OR ON AXIAL STRUT)
AXIAL REFLECTOR TENSIONER > (AND OTHER RIGGING IF NECESSARY)
BAFFLE
SUPPLEMENTAL FRONT OR REAR PROJECTION CAN BE USED IF NECESSARY WITH MOST CONFIGURATIONS, AS CAN NARROW FIELD PROJECTORS FOR ECLIPSE SIMULATIONS, ETC.
< PROJECTOR UNDER FLOOR (AND/OR UNDER BASKET WITH DUAL MIRROR REFLECTOR)
SIMULATED BALLOON FLIGHT EXAMPLE
PROJECTOR CAN INSTEAD BE IN DASHED ENCLOSURE BELOW DOME CEILING, OR ON SIDE (AS SHOWN TO RIGHT) AND UTILIZE CENTRAL DIAGONAL MIRROR.
MIRROR(S) (IF NEC.)
STILL AND/OR MOVIE PROJECTOR
BAFFLE AND STRUT WINDOW.
FLAT MIRROR (IF PROJECTOR NOT ON TOP) >
AXIAL STRUT >
REFLECTOR > AND OPTIONAL PLATE BAFFLE AND RIGGING
ALT. POS. PROJECTOR AND BAFFLE
SPHERICAL, ELLIPTICAL, ETC., OR CYLINDRICAL PROJECTION SURFACE
RAISED FLOOR WITH RAILING
CEILING MOUNTED OMNIRAMIC PROJECTION MIRROR
REFLECTOR CAN BE HIGHER THAN DOME CENTER IF SHAPED FOR PROPER RADIAL SCALE IN OFF-AXIS IMAGE AND RAD. G. FILTER IS USED FOR UNIFORM BRIGHTNESS.
BAFFLED SEMI-SPHERES
ALTERNATE 30-60° PROJECTOR POSITIONS FOR IMAGES FROM CAMERAS POINTING LIKE ANGLE UPWARD
THIS CONCEPT CAN INSTEAD USE TWIN PROJECTORS WITH LONG LENSES WHICH PROJECT ON A CENTRAL BAFFLESD SPHERE OR SEMI-SPHERES
< TWIN 90 DEGREE FISHEYE PROJECTORS > WITH BAFFLES FOR VIEWING AREA & SCREEN PROJECT IMAGES TAKEN WITH TWIN OPPOSING ≥180 DEGREE FISHEYE LENSES
RAISED FLOOR WITH RAILING
SPHERE WITH TWIN CIRCULAR BAFFLE PLATES CROWD AREA BAFFLED BY BLACK PAINT
DUAL OPPOSING 180° FISHEYE PROJECTORS CAN ALSO/INSTEAD BE USED IN CENTER OF THEATER FOR MOST APPLICATIONS.
SIDE MOUNTED OMNIRAMIC PROJECTORS. CONCEPT ALSO APPLICABLE TO VERTICALLY ALIGNED PROJECTORS WHICH HAVE LIKE OR DIFFERING FIELDS OF COVERAGE.
All reflective omniramic imaging and projection with central coverage. Conc. 14 Mar. 1997, 12:55 a.m.
Cassegrain design, but applicable to front projector.
Reverse curve near reflector center images/projects central part of subject and can even overlap to other side of axis (as is desirable when projecting on near surface). → continued.
Shown sideways:
Reverse curve on reflector
Cross Section.
Axial Strut
Central Ray.
Projector.
Supplemental front or rear projection can be used to cover central area.
Top projector and no secondary reflector is also/instead applicable
FLAT OR CURVED SECONDARY REFLECTOR AND BAFFLE >
AXIAL STRUT >
SPHERICAL, ELLIPTICAL, OR HYPERBOLIC REFLECTOR
BAFFLE UNDER
< REFLECTOR
< PROJECTOR (HERE OR BELOW FLOOR)
< HOLLOW COLUMN (THIN IF PROJ. BELOW)
RAISED FLOOR WITH RAILING
FLOOR MOUNTED OMNIRAMIC PROJECTION MIRRORS
(AS VIEWS 6-12 IN MY PATENT D312,263, BUT LARGER AND WITH OPEN CENTRAL HOLE IN PRIMARY REFLECTOR AND CUPPED BAFFLE AROUND SECONDARY REFLECTOR). DESIGN CAN ALSO USE MY HYBRID CENTRAL IMAGING "REFLECTOR" OR ULTRAWIDE UPWARD POINTING (>210°) FISHEYE LENSE.
Axial overlap with a given system can be controlled by the size and/or position of the secondary baffle.


OMNIRAMA (TM) MODEL SC10 (AND SCL10)
340 X 360 DEGREE SOLID CATADIOPTRIC WIDE
ANGLE REFLECTOR WITH CENTRAL COVERAGE
(MODEL SCL10 HAS REDUNDANT CENTRAL COVERAGE)
VERSACORP
JEFFREY R. CHARLES
23 MARCH 1997
(MODEL SCL10) DEEPER NONREFLECTIVE CONCAVE SPOT IN CENTRAL ~15% OF CURVED SECONDARY MIRROR ACTS AS WIDE ANGLE LENS TO COVER CENTRAL 15-70° OF SUBJECT, DEPENDING ON DESIRED IMAGE SCALE.
OUTLINE OF STORAGE CYLINDER
OUTER SURFACE REFRACTS CENTRAL PART OF SUBJECT TO PART OF PRIMARY REFLECTOR BORDERING CENTRAL HOLE. (CAN BE MADE TO OVERLAP)
0°
340°
180°
SOLID OPTIC
0° AXIAL
IMAGING LENS >
~f/11 FOR 35 mm
SHOWN EMBODIMENT CAN BE MOLDED FROM PLASTIC OR MADE WITH FIRE POLISHED GLASS.
INTERNAL
PRIMARY REFLECTOR
SECONDARY MIRROR WITH PAINTED BAFFLE.
OPTIONAL BAFFLES INCLUDE:
* SUN ZAPPER (TM) ADJUSTABLE SOLAR OCCULTING SPHERE (3° APPARENT SIZE)
SPECIFICATIONS:
ANGLE OF VIEW: 340°
ANGULAR OBSTRUCTION: NONE
IMAGED OBSTRUCTION: 20% DIA.
PROJECTION: RADIALLY EQUIDISTANT
RADIAL IMAGE SCALE: 17° per mm
IMAGE CIRCLE DIAMETER: 23 mm
EFFECTIVE FOCAL LENGTH: 4.0 mm
APERTURE RANGE: f/11 TO f/22
PRIMARY REFLECTOR DIAMETER: 10 cm
FOCUSING: WITH REAR LOCK RING
MOUNTING: T-THREAD
FILTER SIZE: SERIES IV AND GEL
DIMENSIONS: 12 cm DIA, 14 cm LONG
(f/5.6 VIDEO VERSION IS ABOUT HALF THIS SIZE)
STANDARD ACCESSORIES:
* CLEAR PLASTIC STORAGE AND SET UP TUBE. (CAN BE LEFT ON WHILE COMPOSING, REMOVED FOR PICTURE)
* CAMERA T-RING REINFORCEMENT
KNURLED GRIP COLLAR
APERTURE ADJUSTMENT
(f/11 TO f/22)
FOCUS ADJUSTMENT
T-THREAD
0° 340°
0° 180°
AXIAL
0-70°
0°
90°
180°
270°
340°
ANGULAR COVERAGE

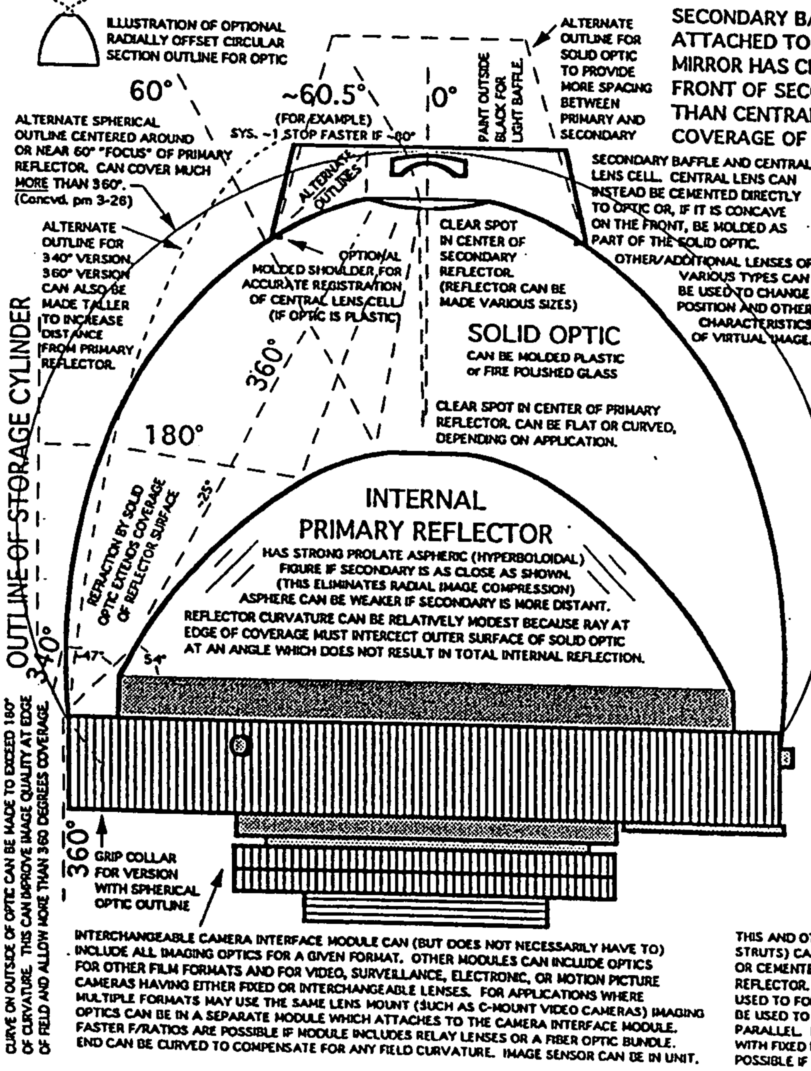
# OMNIRAMA (TM) OMNILENS (TM) MODEL SMCL10 360 X 360 DEGREE SOLID CATADIOPTRIC WIDE ANGLE REFLECTOR WITH CONTINUOUS COVERAGE

VERSACORP
JEFFREY R. CHARLES
23 MARCH 1997

CONCAVE CLEAR AREA IN CENTER OF SECONDARY REFLECTOR ACTS AS CENTRAL WIDE ANGLE LENS. SEEN FROM THE FOCAL PLANE, THE CENTRAL CLEAR AREA APPEARS TO BE SLIGHTLY LARGER THAN THE OBSCURATIONS CAUSED BY THE HOLE IN THE PRIMARY REFLECTOR AND THE OUTSIDE OF THE SECONDARY BAFFLE. THE PART OF THE SOLID OPTIC BORDERING OUTSIDE OF SECONDARY OBSTRUCTION IS NORMAL OR NEARLY NORMAL TO LIGHT PASSING THROUGH THE OUTER SURFACE OF THE OPTIC, SO THERE IS LITTLE OR NO LOCAL RADIAL EFFECT FROM REFRACTION. THE CENTRAL ~60 OR MORE OF COVERAGE IS PROVIDED THROUGH THE CENTRAL CONCAVE CLEAR SPOT. THE OUTER LIMITS OF COVERAGE FROM THE CLEAR CENTRAL CONCAVE SPOT MERGE WITH IMAGE AROUND IT, PRODUCING CONTINUOUS COVERAGE WITHOUT ANY VISIBLE OBSTRUCTION WHATSOEVER. A NEUTRAL DENSITY FILTER AND/OR SMALL NEGATIVE OR OTHER LENS(ES) CAN BE IN FRONT OF CENTER OF SOLID OPTIC TO MODIFY THE CENTRAL IMAGE BRIGHTNESS, SCALE, LOCATION, CURVATURE, COVERAGE, AND/OR PROJECTION. AN EXTERNAL LENS CAN ALSO BE USED FOR ENTIRE CENTRAL WIDE ANGLE IMAGE, (AS SHOWN) ALLOWING THE CLEAR CENTRAL SPOT TO BE FLAT OR MATCH THE CURVATURE OF THE SURROUNDING SECONDARY REFLECTOR. C., pm 3-27: EXTERNAL CENTRAL WIDE ANGLE LENS ELEMENT(S) CAN BE IN A CALIBRATED CELL IN FRONT OF SOLID OPTIC WHICH CAN BE ADJUSTED TO CHANGE THE LONGITUDINAL POSITION OF THE LENS(ES) IN ORDER TO CHANGE THE FIELD OF VIEW AND/OR IMAGE SCALE OF THE CENTRAL PART OF THE IMAGE. THIS ALLOWS ADJUSTMENT OF THE CENTRAL LENS COVERAGE TO COMPENSATE FOR PARALLAX BETWEEN IT AND THE SOLID OPTIC AT VARIOUS SUBJECT DISTANCES, FACILITATING AN EXACT MATCH IN THE IMAGES FROM BOTH AT THE TRANSITION ZONE.




SECONDARY BAFFLE AND CENTRAL LENS CELL ARE ATTACHED TO FRONT OF SOLID OPTIC. SECONDARY MIRROR HAS CENTRAL CLEAR SPOT. CENTRAL LENS IN FRONT OF SECONDARY COVERS SLIGHTLY MORE ANGLE THAN CENTRAL OBSTRUCTION TO PROVIDE COMPLETE COVERAGE OF SUBJECTS AT MODERATE DISTANCES.




## SPECIFICATIONS:

ANGLE OF VIEW: 360°
ANGULAR OBSTRUCTION: NONE
IMAGED OBSTRUCTION: NONE
PROJECTION: EQUIDISTANT
RADIAL IMAGE SCALE: 16° per mm
IMAGE CIRCLE DIAMETER: 23 mm
EFFECTIVE FOCAL LENGTH: 4.0 mm
APERTURE RANGE: f/11 TO f/22
PRIMARY REFLECTOR DIAMETER: 10 cm
FOCUSING: WITH REAR LOCK RING
MOUNTING: T-THREAD
FILTER SIZE: SERIES IV
DIMENSIONS: 12 cm DIA, 13 cm LONG
(CAN BE ANY SIZE - EVEN MINIATURE FOR MEDICAL OPTICS)

## STANDARD ACCESSORIES:

* CLEAR PLASTIC STORAGE AND SET UP TUBE. (CAN BE LEFT ON WHILE COMPOSING, REMOVED FOR PICTURE)
* CAMERA T-RING REINFORCEMENT

## OPTIONAL ACCESSORIES:

* SUN ZAPPER (TM) ADJUSTABLE SOLAR OCCULTING SPHERE. (ON END OF THIN POSITIONABLE AND BENDABLE WIRE)

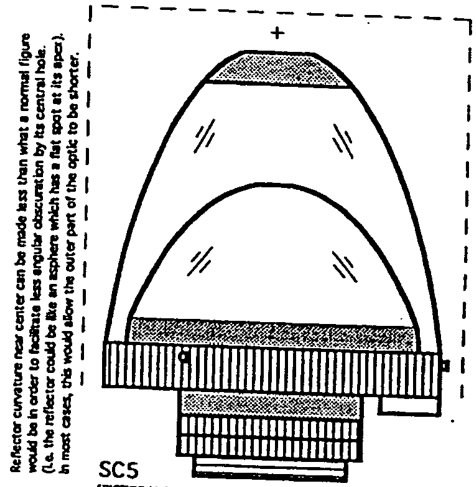
KNURLED GRIP COLLAR
APERTURE ADJUSTMENT (F/11 TO F/22)
FOCUS ADJUSTMENT
T-THREAD

INTERCHANGEABLE CAMERA INTERFACE MODULE CAN (BUT DOES NOT NECESSARILY HAVE TO) INCLUDE ALL IMAGING OPTICS FOR A GIVEN FORMAT. OTHER MODULES CAN INCLUDE OPTICS FOR OTHER FILM FORMATS AND FOR VIDEO, SURVEILLANCE, ELECTRONIC, OR MOTION PICTURE CAMERAS HAVING EITHER FIXED OR INTERCHANGEABLE LENSES. FOR APPLICATIONS WHERE MULTIPLE FORMATS MAY USE THE SAME LENS MOUNT (SUCH AS C-MOUNT VIDEO CAMERAS) IMAGING OPTICS CAN BE IN A SEPARATE MODULE WHICH ATTACHES TO THE CAMERA INTERFACE MODULE. FASTER F/RATIOS ARE POSSIBLE IF MODULE INCLUDES RELAY LENSES OR A FIBER OPTIC BUNDLE. END CAN BE CURVED TO COMPENSATE FOR ANY FIELD CURVATURE. IMAGE SENSOR CAN BE IN UNIT.

THIS AND OTHER EMBODIMENTS (INCLUDING THOSE WITH AXIAL OR SIDE STRUTS) CAN HAVE AN IMAGING LENS STALK WHICH IS EITHER MOLDED OR CEMENTED BEHIND THE CLEAR SPOT IN THE CENTER OF THE PRIMARY REFLECTOR. IMAGING LENS(ES) CAN COMPRISE ALL OR PART OF OPTICS USED TO FORM THE REAL IMAGE AT THE FOCAL PLANE, OR IT/THEY CAN BE USED TO CAUSE RAYS BEHIND THE OPTIC TO BE DIVERGENT OR PARALLEL. PARALLEL RAYS WOULD ALLOW "AFOCAL" USE OF THE OPTIC WITH FIXED LENS CAMERAS, PROJECTORS, ETC. FASTER F/RATIOS ARE POSSIBLE IF LENS STALK EXTENDS TO NEAR FOCAL PLANE.

OMNIRAMA (TM) OMNILENS (TM) MODELS SC AND SCL 5 & 6
340 (or even 360) X 360 DEGREE SOLID CATADIOPTRIC WIDE
ANGLE REFLECTORS WITH CENTRAL COVERAGE FOR VIDEO, ETC.
(SCL MODELS HAVE REDUNDANT OR MERGED CENTRAL COVERAGE)
ALL VERSIONS ARE APPLICABLE TO ORIGINAL IMAGING AND TO PRINTING, PROJECTION, ETC.

VERSACORP
JEFFREY R. CHARLES
24 MARCH 1997




SC5
(PICTORAL VIEW - PRIMARY REFLECTOR SURFACE SHOWN AS IT APPEARS THROUGH THE SOLID OPTIC)

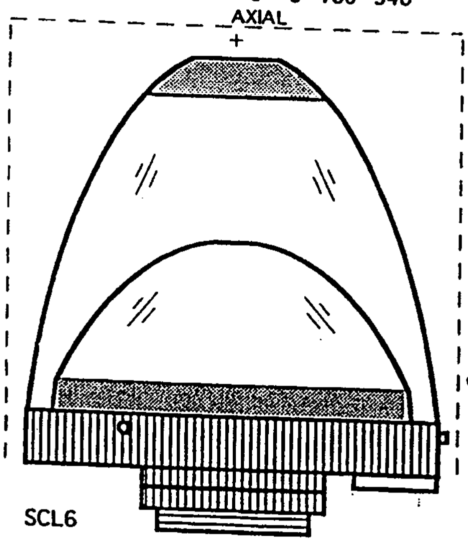
FOCAL PLANE
0° 0° 180° 340°
AXIAL

< SECONDARY MIRROR WITH PAINTED BAFFLE.

SPECIFICATIONS:
ANGLE OF VIEW: 340° (360° POSSIBLE IF NO DRAFT IN DIES)
ANGULAR CENTRAL OBSTRUCTION: NONE
IMAGED OBSTRUCTION: 20% DIA. (SCL version with merged central image has none)
PROJECTION: RADIALLY EQUIDISTANT
RADIAL IMAGE SCALE: 88° per mm (SCL with merged central image ~ 70° per mm)
IMAGE CIRCLE DIAMETER: 4.5 mm (for 1/2" format sensor) (3.1 mm for 1/3")
EFFECTIVE FOCAL LENGTH: 0.7 mm (SCL with merged central image ~ 0.9 mm)
APERTURE RANGE: f/5.6 TO f/22 (SC5-f/8-22) (Either is 1 f/stop faster for 1/3")
PRIMARY REFLECTOR DIAMETER: 5-6 cm
FOCUSING: WITH REAR LOCK RING
MOUNTING: C MOUNT, CS MOUNT, CUSTOM
FILTER SIZE: GEL. FILTERS
DIMENSIONS: 6 cm DIA, 7 cm LONG (SC5)
(35 mm & OTHER STILL PHOTO VERSIONS ~ ABOUT TWICE THIS SIZE)

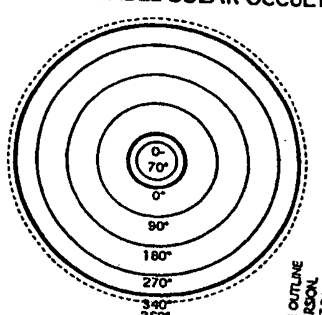
SMALL (~15%) CONCAVE CLEAR AREA IN CENTER OF SECONDARY REFLECTOR ACTS AS CENTRAL WIDE ANGLE LENS. UNIT CAN INSTEAD BE MADE SO PART OF SOLID OPTIC BORDERING OUTSIDE OF SECONDARY OBSTRUCTION IS NORMAL TO LIGHT ENTERING THE OPTIC, AND THE CENTRAL CONCAVE CLEAR SPOT CAN BE MADE SLIGHTLY LARGER. THIS WILL OBSTRUCT THE CENTRAL ~60-70° OF REFLECTOR COVERAGE, BUT THE OUTER LIMITS OF COVERAGE FROM THE CLEAR CENTRAL CONCAVE SPOT WILL FILL IN THIS AREA AND MERGE WITH IMAGE AROUND IT, PRODUCING CONTINUOUS COVERAGE WITHOUT ANY VISIBLE OBSTRUCTION AT ALL. A NEUTRAL DENSITY FILTER AND/OR A SMALL NEGATIVE OR OTHER LENS CAN BE IN FRONT OF CENTER OF SOLID OPTIC TO MODIFY CENTRAL IMAGE BRIGHTNESS, SCALE, LOCATION, COVERAGE, AND/OR PROJECTION. LENS COULD ALSO REPLACE CONCAVE SPOT.

OPTIONAL ACCESSORIES:
* C-MOUNTS W/ OTHER FORMAT OPTICS
* CLEAR PLASTIC STORAGE AND SET UP TUBE. (CAN BE LEFT ON WHILE COMPOSING, REMOVED FOR USE)
* ADJUSTABLE SOLAR OCCULTING SPHERE



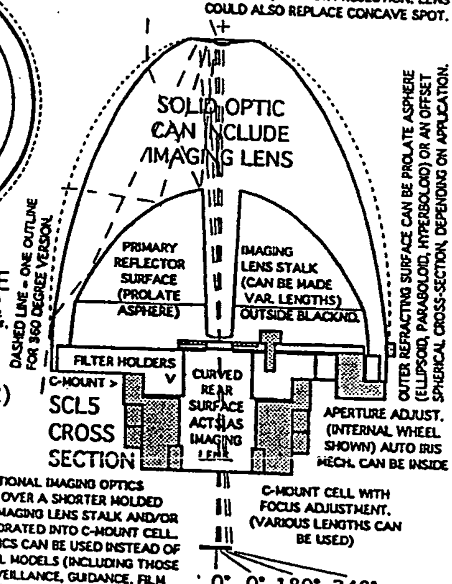

SCL6

FOCAL PLANE
340° 180° 0° 0°
AXIAL




ANGULAR COVERAGE
(If redundant central coverage) Merged central coverage is simple 0 to 340 or 360° continuous coverage.
KNURLED GRIP COLLAR
OPTIONAL APERTURE ADJUST. (f/5.6 TO f/22)
FOCUS ADJUSTMENT
C or CS MOUNT

UNITS FOR FORMATS SMALLER THAN 1/2 INCH CAN HAVE FASTER f/RATIOS. GIVEN SIZE UNIT CAN HAVE FASTER f/RATIO IF RELATIVE SIZE OF CENTRAL OBSCURATION IMAGE IS LARGER. FULL FRAME COVERAGE IS POSSIBLE BY USING REAR OPTICS DESIGNED FOR LARGER FORMAT. AFOCAL OR OTHER RELAY LENS CAN BE USED TO ADAPT ANY MODEL TO A FIXED LENS CAMERA. SINGLE PIECE "OMNIOPTICS" CAN ALSO BE MADE FOR AFOCAL USE.

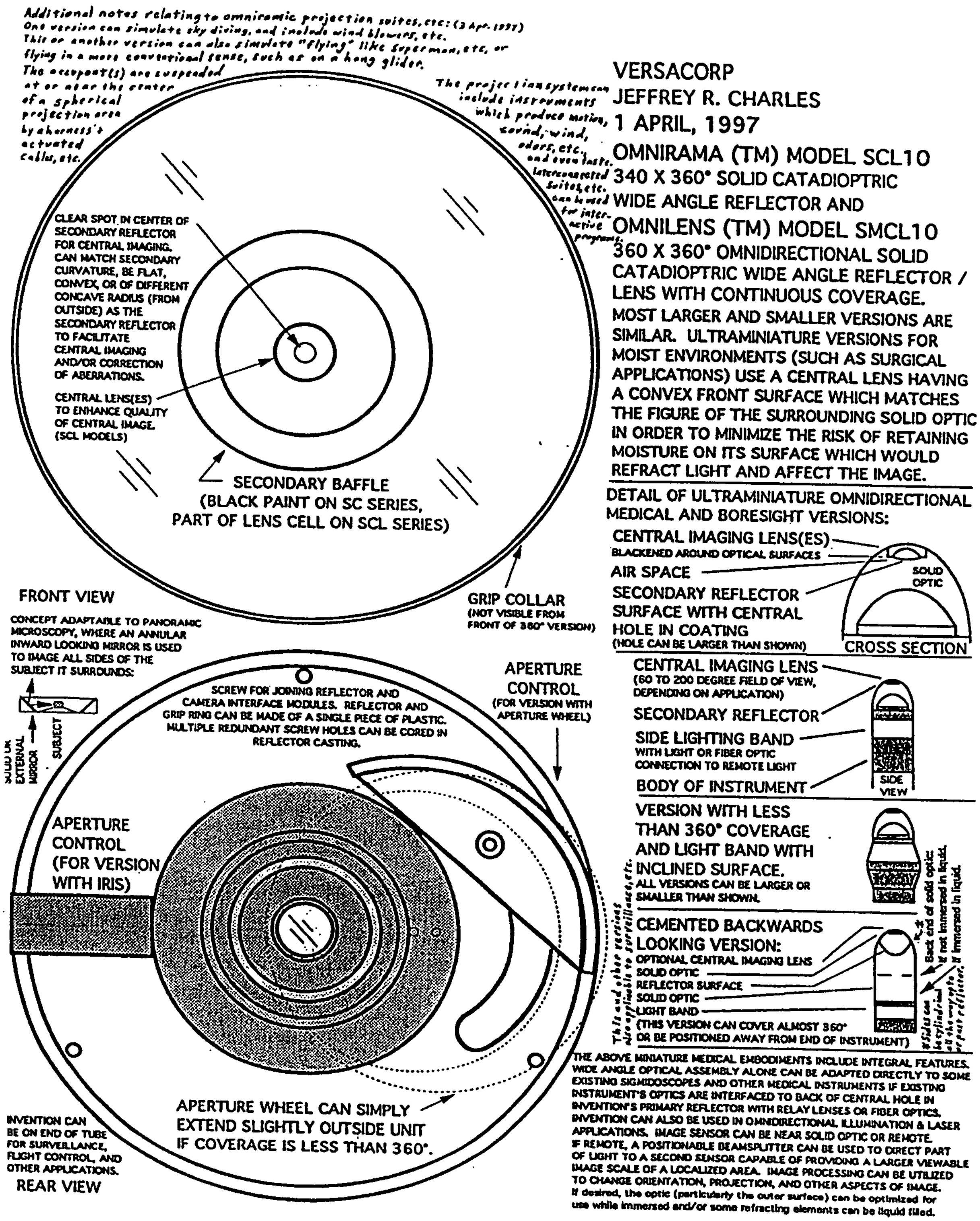



SCL5 CROSS SECTION

C-MOUNT CELL WITH FOCUS ADJUSTMENT. (VARIOUS LENGTHS CAN BE USED)

0° 0° 180° 340°+
AXIAL

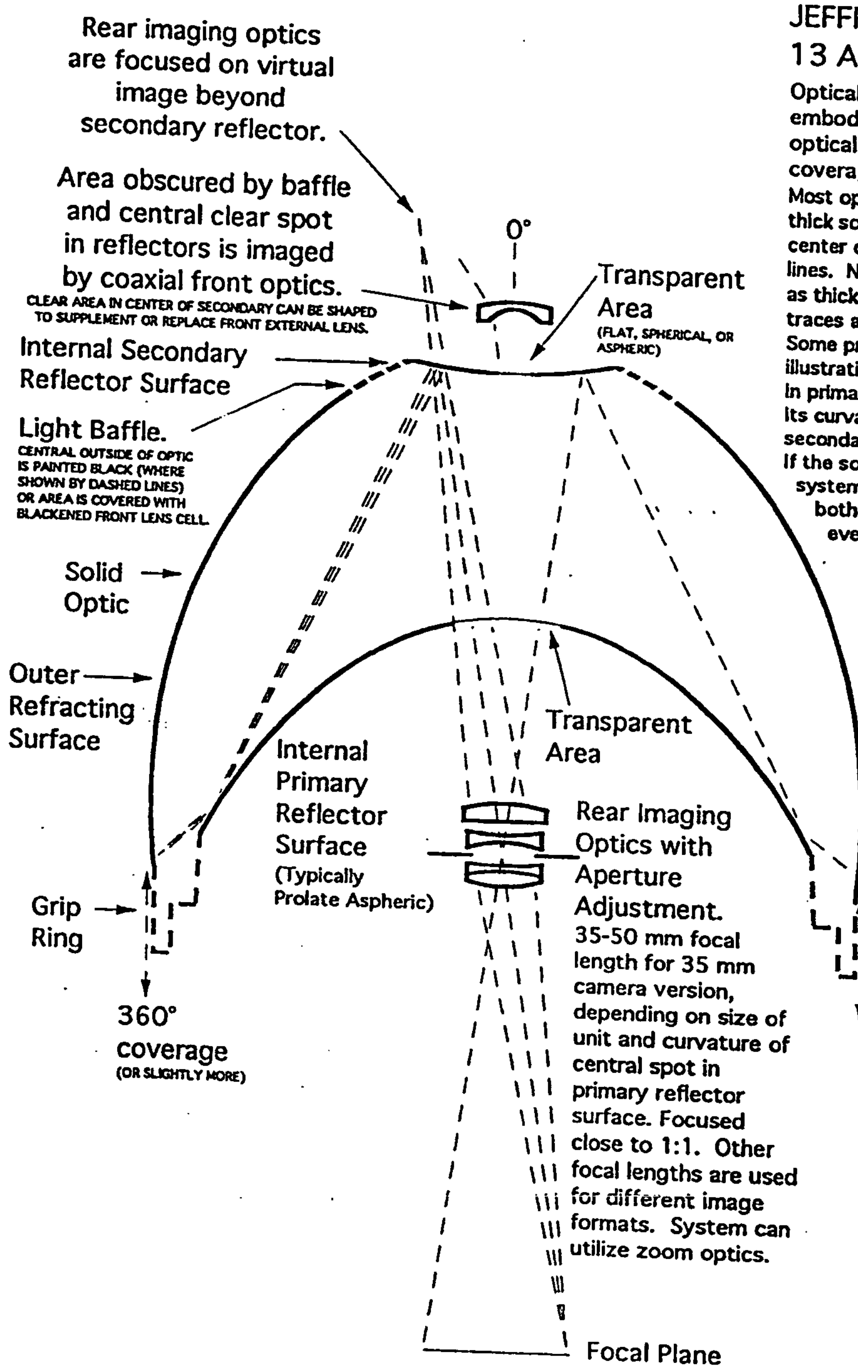
ADDITIONAL IMAGING OPTICS CAN FIT OVER A SHORTER MOLDED INTERNAL IMAGING LENS STALK AND/OR BE INCORPORATED INTO C-MOUNT CELL. OTHER OPTICS CAN BE USED INSTEAD OF STALK. ALL MODELS (INCLUDING THOSE FOR SURVEILLANCE, GUIDANCE, FILM CAMERAS, ETC.) CAN BE MADE TO HAVE ANY COMBINATION OF SHOWN FEATURES.
Entire product can be made of plastic if desired.



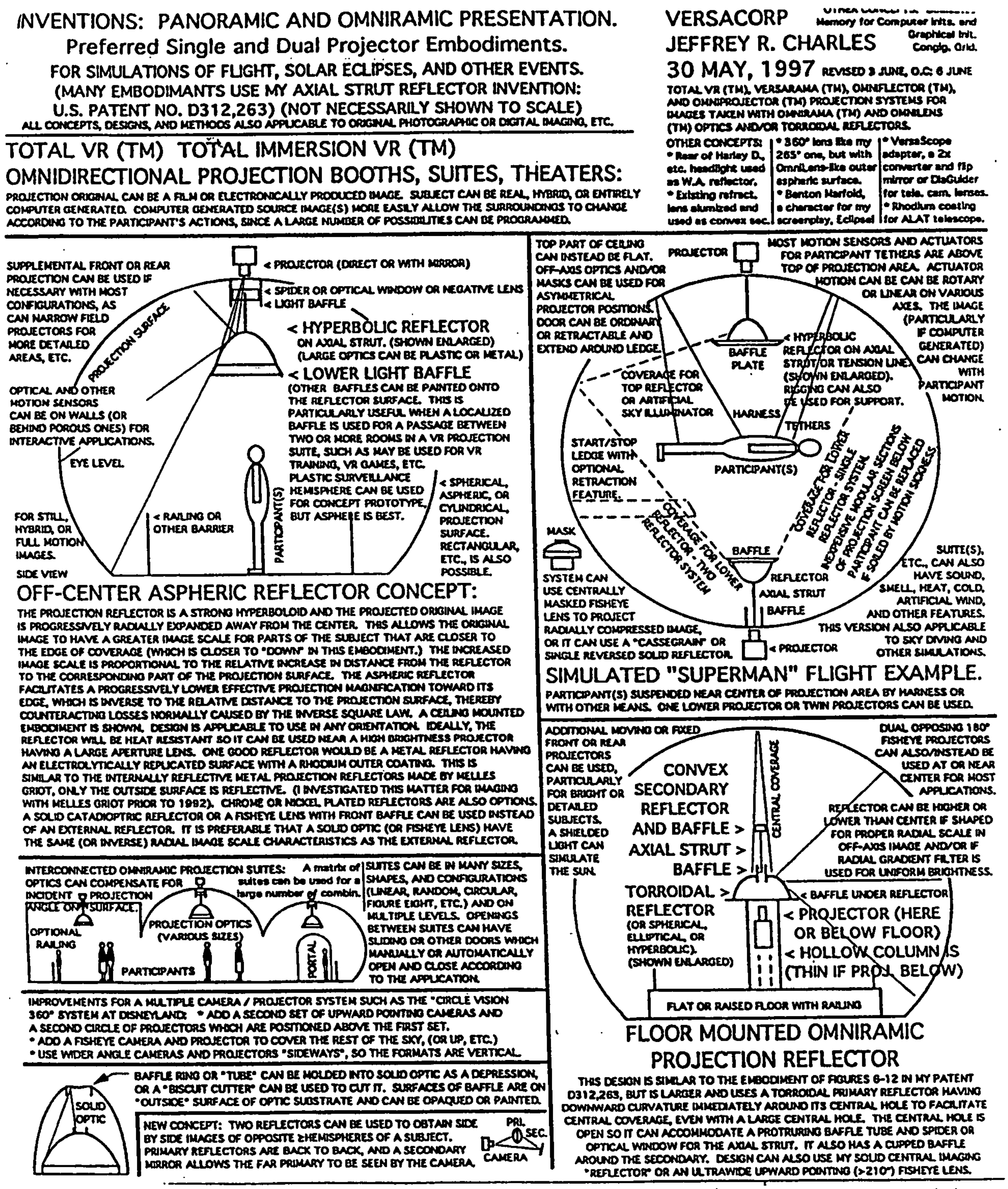
Additional notes relating to omniramic projection suites, etc: (3 Apr. 1997)
One version can simulate sky diving, and include wind blowers, etc.
This or another version can also simulate "flying" like Superman, etc, or flying in a more conventional sense, such as on a hang glider.
The occupant(s) are suspended at or near the center of a spherical projection area by a harness's actuated cables, etc.
The projection system can include instruments which produce motion, sound, wind, odors, etc., and even taste. Interconnected suites, etc. can be used for interactive programs.
VERSACORP
JEFFREY R. CHARLES
1 APRIL, 1997
OMNIRAMA (TM) MODEL SCL10
340 X 360° SOLID CATADIOPTRIC WIDE ANGLE REFLECTOR AND
OMNILENS (TM) MODEL SMCL10
360 X 360° OMNIDIRECTIONAL SOLID CATADIOPTRIC WIDE ANGLE REFLECTOR / LENS WITH CONTINUOUS COVERAGE.
MOST LARGER AND SMALLER VERSIONS ARE SIMILAR. ULTRAMINIATURE VERSIONS FOR MOIST ENVIRONMENTS (SUCH AS SURGICAL APPLICATIONS) USE A CENTRAL LENS HAVING A CONVEX FRONT SURFACE WHICH MATCHES THE FIGURE OF THE SURROUNDING SOLID OPTIC IN ORDER TO MINIMIZE THE RISK OF RETAINING MOISTURE ON ITS SURFACE WHICH WOULD REFRACT LIGHT AND AFFECT THE IMAGE.
CLEAR SPOT IN CENTER OF SECONDARY REFLECTOR FOR CENTRAL IMAGING. CAN MATCH SECONDARY CURVATURE, BE FLAT, CONVEX, OR OF DIFFERENT CONCAVE RADIUS (FROM OUTSIDE) AS THE SECONDARY REFLECTOR TO FACILITATE CENTRAL IMAGING AND/OR CORRECTION OF ABERRATIONS.
CENTRAL LENS(ES) TO ENHANCE QUALITY OF CENTRAL IMAGE. (SCL MODELS)
SECONDARY BAFFLE (BLACK PAINT ON SC SERIES, PART OF LENS CELL ON SCL SERIES)
FRONT VIEW
GRIP COLLAR (NOT VISIBLE FROM FRONT OF 360° VERSION)
DETAIL OF ULTRAMINIATURE OMNIDIRECTIONAL MEDICAL AND BORESIGHT VERSIONS:
CENTRAL IMAGING LENS(ES)
BLACKENED AROUND OPTICAL SURFACES
AIR SPACE
SOLID OPTIC
SECONDARY REFLECTOR SURFACE WITH CENTRAL HOLE IN COATING
(HOLE CAN BE LARGER THAN SHOWN)
CROSS SECTION
CENTRAL IMAGING LENS
(60 TO 200 DEGREE FIELD OF VIEW, DEPENDING ON APPLICATION)
SECONDARY REFLECTOR
SIDE LIGHTING BAND
WITH LIGHT OR FIBER OPTIC CONNECTION TO REMOTE LIGHT
BODY OF INSTRUMENT
SIDE VIEW
VERSION WITH LESS THAN 360° COVERAGE AND LIGHT BAND WITH INCLINED SURFACE.
ALL VERSIONS CAN BE LARGER OR SMALLER THAN SHOWN.
This and other versions also applicable to surveillance, etc.
CEMENTED BACKWARDS LOOKING VERSION:
OPTIONAL CENTRAL IMAGING LENS
SOLID OPTIC
REFLECTOR SURFACE
SOLID OPTIC
LIGHT BAND
(THIS VERSION CAN COVER ALMOST 360° OR BE POSITIONED AWAY FROM END OF INSTRUMENT)
Back end of solid optic: If not immersed in liquid. If immersed in liquid.
# Sides can be cylindrical all the way up to or past reflector.
CONCEPT ADAPTABLE TO PANORAMIC MICROSCOPY, WHERE AN ANNULAR INWARD LOOKING MIRROR IS USED TO IMAGE ALL SIDES OF THE SUBJECT IT SURROUNDS:
SOLID OR EXTERNAL MIRROR
SUBJECT
SCREW FOR JOINING REFLECTOR AND CAMERA INTERFACE MODULES. REFLECTOR AND GRIP RING CAN BE MADE OF A SINGLE PIECE OF PLASTIC. MULTIPLE REDUNDANT SCREW HOLES CAN BE CORED IN REFLECTOR CASTING.
APERTURE CONTROL (FOR VERSION WITH APERTURE WHEEL)
APERTURE CONTROL (FOR VERSION WITH IRIS)
APERTURE WHEEL CAN SIMPLY EXTEND SLIGHTLY OUTSIDE UNIT IF COVERAGE IS LESS THAN 360°.
INVENTION CAN BE ON END OF TUBE FOR SURVEILLANCE, FLIGHT CONTROL, AND OTHER APPLICATIONS.
REAR VIEW
THE ABOVE MINIATURE MEDICAL EMBODIMENTS INCLUDE INTEGRAL FEATURES. WIDE ANGLE OPTICAL ASSEMBLY ALONE CAN BE ADAPTED DIRECTLY TO SOME EXISTING SIGMIDOSCOPES AND OTHER MEDICAL INSTRUMENTS IF EXISTING INSTRUMENT'S OPTICS ARE INTERFACED TO BACK OF CENTRAL HOLE IN INVENTION'S PRIMARY REFLECTOR WITH RELAY LENSES OR FIBER OPTICS. INVENTION CAN ALSO BE USED IN OMNIDIRECTIONAL ILLUMINATION & LASER APPLICATIONS. IMAGE SENSOR CAN BE NEAR SOLID OPTIC OR REMOTE. IF REMOTE, A POSITIONABLE BEAMSPLITTER CAN BE USED TO DIRECT PART OF LIGHT TO A SECOND SENSOR CAPABLE OF PROVIDING A LARGER VIEWABLE IMAGE SCALE OF A LOCALIZED AREA. IMAGE PROCESSING CAN BE UTILIZED TO CHANGE ORIENTATION, PROJECTION, AND OTHER ASPECTS OF IMAGE.
If desired, the optic (particularly the outer surface) can be optimized for use while immersed and/or some refracting elements can be liquid filled.

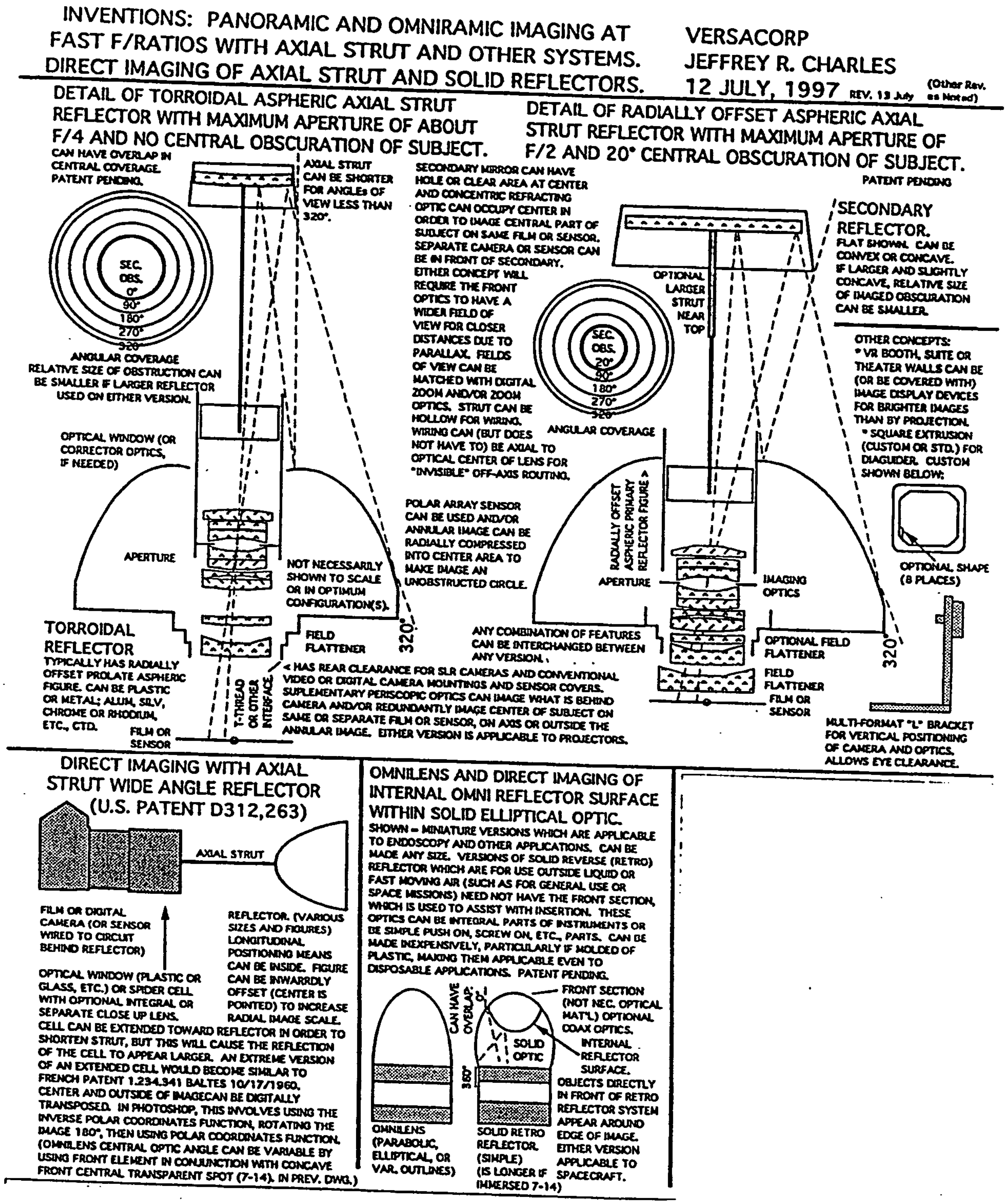
VERSACORP
JEFFREY R. CHARLES
13 April, 1997

Optical surface diagram for one embodiment of an omnidirectional optical system having continuous coverage for a 35 mm film camera. Most optical surfaces are shown as thick solid lines. Transparent areas in center of reflectors are shown as thin lines. Non-optical surfaces are shown as thick dashed lines. Approximate ray traces are shown as thin dashed lines. Some proportions may be enlarged for illustrative purposes. Transparent area in primary reflector can be smaller if its curvature is increased and/or if secondary reflector is smaller and/or if the solid optic is longer. Optical system can be scaled substantially, both wholly and proportionally. Can even be made in microscopic sizes.




Shown optical system is rotationally symmetrical. Concept is also applicable to rotating line scan imaging systems. If a linear or predominantly linear sensor array is rotated behind the shown optics, a "straight" panoramic image of the entire sphere around the optic will result. If the sensor is the full width of the image, only half a rotation will be required to image an entire sphere. If the sensor length is equal to the radius of the image, a full sphere can be imaged in one rotation. The concept is also applicable to systems where both the sensor and the optics rotate. In this case, only a "slice" of the optical system having a width equal to its own aperture is required. Since the sensor width determines nonradial resolution, such a "slice" of at least the solid optic can *possibly* be a simple cross section analogous to a cylindrical lens. Only about half of solid optic is needed if unit turns a full rotation.
(This sect. wrt. 14 April, 1997. C. prev.)


INVENTIONS: PANORAMIC AND OMNIRAMIC PRESENTATION.
Preferred Single and Dual Projector Embodiments.
FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS.
(MANY EMBODIMANTS USE MY AXIAL STRUT REFLECTOR INVENTION:
U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)
ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC.
VERSACORP
JEFFREY R. CHARLES
30 MAY, 1997 REVISED 3 JUNE, O.C. 6 JUNE
Memory for Computer Ints. and Graphical Int. Congig. Grid.
TOTAL VR (TM), VERSARAMA (TM), OMNIFLECTOR (TM), AND OMNIPROJECTOR (TM) PROJECTION SYSTEMS FOR IMAGES TAKEN WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS.
OTHER CONCEPTS: • Rear of Harley D. etc. headlight used as W.A. reflector. • Existing refract. lens aluminized and used as convex sec.
• 360° lens like my 265° one, but with OmniLens-like outer aspheric surface. • Benton Harfold, a character for my screenplay, Eclipse!
• VersaScope adapter, a 2x converter and flip mirror or DiaGuider for tele. cam. lenses. • Rhodium coating for ALAT telescope.
TOTAL VR (TM) TOTAL IMMERSION VR (TM)
OMNIDIRECTIONAL PROJECTION BOOTHS, SUITES, THEATERS:
PROJECTION ORIGINAL CAN BE A FILM OR ELECTRONICALLY PRODUCED IMAGE. SUBJECT CAN BE REAL, HYBRID, OR ENTIRELY COMPUTER GENERATED. COMPUTER GENERATED SOURCE IMAGE(S) MORE EASILY ALLOW THE SURROUNDINGS TO CHANGE ACCORDING TO THE PARTICIPANT'S ACTIONS, SINCE A LARGE NUMBER OF POSSIBILITIES CAN BE PROGRAMMED.
SUPPLEMENTAL FRONT OR REAR PROJECTION CAN BE USED IF NECESSARY WITH MOST CONFIGURATIONS, AS CAN NARROW FIELD PROJECTORS FOR MORE DETAILED AREAS, ETC.
< PROJECTOR (DIRECT OR WITH MIRROR)
< SPIDER OR OPTICAL WINDOW OR NEGATIVE LENS
< LIGHT BAFFLE
PROJECTION SURFACE
< HYPERBOLIC REFLECTOR
ON AXIAL STRUT. (SHOWN ENLARGED) (LARGE OPTICS CAN BE PLASTIC OR METAL)
< LOWER LIGHT BAFFLE
(OTHER BAFFLES CAN BE PAINTED ONTO THE REFLECTOR SURFACE. THIS IS PARTICULARLY USEFUL WHEN A LOCALIZED BAFFLE IS USED FOR A PASSAGE BETWEEN TWO OR MORE ROOMS IN A VR PROJECTION SUITE, SUCH AS MAY BE USED FOR VR TRAINING, VR GAMES, ETC.
OPTICAL AND OTHER MOTION SENSORS CAN BE ON WALLS (OR BEHIND POROUS ONES) FOR INTERACTIVE APPLICATIONS.
EYE LEVEL
PLASTIC SURVEILLANCE HEMISPHERE CAN BE USED FOR CONCEPT PROTOTYPE, BUT ASPHERE IS BEST.
< SPHERICAL, ASPHERIC, OR CYLINDRICAL, PROJECTION SURFACE. RECTANGULAR, ETC., IS ALSO POSSIBLE.
PARTICIPANT(S)
FOR STILL, HYBRID, OR FULL MOTION IMAGES.
< RAILING OR OTHER BARRIER
SIDE VIEW
OFF-CENTER ASPHERIC REFLECTOR CONCEPT:
THE PROJECTION REFLECTOR IS A STRONG HYPERBOLOID AND THE PROJECTED ORIGINAL IMAGE IS PROGRESSIVELY RADIALLY EXPANDED AWAY FROM THE CENTER. THIS ALLOWS THE ORIGINAL IMAGE TO HAVE A GREATER IMAGE SCALE FOR PARTS OF THE SUBJECT THAT ARE CLOSER TO THE EDGE OF COVERAGE (WHICH IS CLOSER TO "DOWN" IN THIS EMBODIMENT.) THE INCREASED IMAGE SCALE IS PROPORTIONAL TO THE RELATIVE INCREASE IN DISTANCE FROM THE REFLECTOR TO THE CORRESPONDING PART OF THE PROJECTION SURFACE. THE ASPHERIC REFLECTOR FACILITATES A PROGRESSIVELY LOWER EFFECTIVE PROJECTION MAGNIFICATION TOWARD ITS EDGE, WHICH IS INVERSE TO THE RELATIVE DISTANCE TO THE PROJECTION SURFACE, THEREBY COUNTERACTING LOSSES NORMALLY CAUSED BY THE INVERSE SQUARE LAW. A CEILING MOUNTED EMBODIMENT IS SHOWN. DESIGN IS APPLICABLE TO USE IN ANY ORIENTATION. IDEALLY, THE REFLECTOR WILL BE HEAT RESISTANT SO IT CAN BE USED NEAR A HIGH BRIGHTNESS PROJECTOR HAVING A LARGE APERTURE LENS. ONE GOOD REFLECTOR WOULD BE A METAL REFLECTOR HAVING AN ELECTROLYTICALLY REPLICATED SURFACE WITH A RHODIUM OUTER COATING. THIS IS SIMILAR TO THE INTERNALLY REFLECTIVE METAL PROJECTION REFLECTORS MADE BY MELLES GRIOT, ONLY THE OUTSIDE SURFACE IS REFLECTIVE. (I INVESTIGATED THIS MATTER FOR IMAGING WITH MELLES GRIOT PRIOR TO 1992). CHROME OR NICKEL PLATED REFLECTORS ARE ALSO OPTIONS. A SOLID CATADIOPTRIC REFLECTOR OR A FISHEYE LENS WITH FRONT BAFFLE CAN BE USED INSTEAD OF AN EXTERNAL REFLECTOR. IT IS PREFERABLE THAT A SOLID OPTIC (OR FISHEYE LENS) HAVE THE SAME (OR INVERSE) RADIAL IMAGE SCALE CHARACTERISTICS AS THE EXTERNAL REFLECTOR.
TOP PART OF CEILING CAN INSTEAD BE FLAT. OFF-AXIS OPTICS AND/OR MASKS CAN BE USED FOR ASYMMETRICAL PROJECTOR POSITIONS. DOOR CAN BE ORDINARY OR RETRACTABLE AND EXTEND AROUND LEDGE.
PROJECTOR
MOST MOTION SENSORS AND ACTUATORS FOR PARTICIPANT TETHERS ARE ABOVE TOP OF PROJECTION AREA. ACTUATOR MOTION CAN BE CAN BE ROTARY OR LINEAR ON VARIOUS AXES. THE IMAGE (PARTICULARLY IF COMPUTER GENERATED) CAN CHANGE WITH PARTICIPANT MOTION.
BAFFLE PLATE
< HYPERBOLIC REFLECTOR ON AXIAL STRUT/OR TENSION LINE (SHOWN ENLARGED). RIGGING CAN ALSO BE USED FOR SUPPORT.
COVERAGE FOR TOP REFLECTOR OR ARTIFICIAL SKY ILLUMINATOR
HARNESS
TETHERS
START/STOP LEDGE WITH OPTIONAL RETRACTION FEATURE.
PARTICIPANT(S)
COVERAGE FOR LOWER REFLECTOR - SINGLE REFLECTOR SYSTEM. INEXPENSIVE MODULAR SECTIONS OF PROJECTION SCREEN BELOW PARTICIPANT CAN BE REPLACED IF SOILED BY MOTION SICKNESS.
COVERAGE FOR LOWER REFLECTOR - TWO REFLECTOR SYSTEM
MASK
BAFFLE
REFLECTOR
AXIAL STRUT
BAFFLE
SYSTEM CAN USE CENTRALLY MASKED FISHEYE LENS TO PROJECT RADIALLY COMPRESSED IMAGE, OR IT CAN USE A "CASSEGRAIN" OR SINGLE REVERSED SOLID REFLECTOR.
< PROJECTOR
SUITE(S), ETC., CAN ALSO HAVE SOUND, SMELL, HEAT, COLD, ARTIFICIAL WIND, AND OTHER FEATURES. THIS VERSION ALSO APPLICABLE TO SKY DIVING AND OTHER SIMULATIONS.
SIMULATED "SUPERMAN" FLIGHT EXAMPLE.
PARTICIPANT(S) SUSPENDED NEAR CENTER OF PROJECTION AREA BY HARNESS OR WITH OTHER MEANS. ONE LOWER PROJECTOR OR TWIN PROJECTORS CAN BE USED.
INTERCONNECTED OMNIRAMIC PROJECTION SUITES: OPTICS CAN COMPENSATE FOR INCIDENT PROJECTION ANGLE ON SURFACE.
A matrix of suites can be used for a large number of combin.
OPTIONAL RAILING
PROJECTION OPTICS (VARIOUS SIZES)
PARTICIPANTS
PORTAL
SUITES CAN BE IN MANY SIZES, SHAPES, AND CONFIGURATIONS (LINEAR, RANDOM, CIRCULAR, FIGURE EIGHT, ETC.) AND ON MULTIPLE LEVELS. OPENINGS BETWEEN SUITES CAN HAVE SLIDING OR OTHER DOORS WHICH MANUALLY OR AUTOMATICALLY OPEN AND CLOSE ACCORDING TO THE APPLICATION.
IMPROVEMENTS FOR A MULTIPLE CAMERA / PROJECTOR SYSTEM SUCH AS THE "CIRCLE VISION 360° SYSTEM AT DISNEYLAND: • ADD A SECOND SET OF UPWARD POINTING CAMERAS AND A SECOND CIRCLE OF PROJECTORS WHICH ARE POSITIONED ABOVE THE FIRST SET.
• ADD A FISHEYE CAMERA AND PROJECTOR TO COVER THE REST OF THE SKY, (OR UP, ETC.)
• USE WIDER ANGLE CAMERAS AND PROJECTORS "SIDEWAYS", SO THE FORMATS ARE VERTICAL.
BAFFLE RING OR "TUBE" CAN BE MOLDED INTO SOLID OPTIC AS A DEPRESSION, OR A "BISCUIT CUTTER" CAN BE USED TO CUT IT. SURFACES OF BAFFLE ARE ON "OUTSIDE" SURFACE OF OPTIC SUBSTRATE AND CAN BE OPAQUED OR PAINTED.
SOLID OPTIC
NEW CONCEPT: TWO REFLECTORS CAN BE USED TO OBTAIN SIDE BY SIDE IMAGES OF OPPOSITE ≥HEMISPHERES OF A SUBJECT. PRIMARY REFLECTORS ARE BACK TO BACK, AND A SECONDARY MIRROR ALLOWS THE FAR PRIMARY TO BE SEEN BY THE CAMERA.
PRI.
SEC.
CAMERA
ADDITIONAL MOVING OR FIXED FRONT OR REAR PROJECTORS CAN BE USED, PARTICULARLY FOR BRIGHT OR DETAILED SUBJECTS. A SHIELDED LIGHT CAN SIMULATE THE SUN.
CONVEX SECONDARY REFLECTOR AND BAFFLE >
AXIAL STRUT >
BAFFLE >
CENTRAL COVERAGE
DUAL OPPOSING 180° FISHEYE PROJECTORS CAN ALSO/INSTEAD BE USED AT OR NEAR CENTER FOR MOST APPLICATIONS.
REFLECTOR CAN BE HIGHER OR LOWER THAN CENTER IF SHAPED FOR PROPER RADIAL SCALE IN OFF-AXIS IMAGE AND/OR IF RADIAL GRADIENT FILTER IS USED FOR UNIFORM BRIGHTNESS.
TORROIDAL > REFLECTOR
(OR SPHERICAL, ELLIPTICAL, OR HYPERBOLIC). (SHOWN ENLARGED)
< BAFFLE UNDER REFLECTOR
< PROJECTOR (HERE OR BELOW FLOOR)
< HOLLOW COLUMN IS (THIN IF PROJ. BELOW)
FLAT OR RAISED FLOOR WITH RAILING
FLOOR MOUNTED OMNIRAMIC PROJECTION REFLECTOR
THIS DESIGN IS SIMILAR TO THE EMBODIMENT OF FIGURES 6-12 IN MY PATENT D312,263, BUT IS LARGER AND USES A TORROIDAL PRIMARY REFLECTOR HAVING DOWNWARD CURVATURE IMMEDIATELY AROUND ITS CENTRAL HOLE TO FACILITATE CENTRAL COVERAGE, EVEN WITH A LARGE CENTRAL HOLE. THE CENTRAL HOLE IS OPEN SO IT CAN ACCOMMODATE A PROTRURING BAFFLE TUBE AND SPIDER OR OPTICAL WINDOW FOR THE AXIAL STRUT. IT ALSO HAS A CUPPED BAFFLE AROUND THE SECONDARY. DESIGN CAN ALSO USE MY SOLID CENTRAL IMAGING "REFLECTOR" OR AN ULTRAWIDE UPWARD POINTING (>210°) FISHEYE LENS.


INVENTIONS: PANORAMIC AND OMNIRAMIC IMAGING AT FAST F/RATIOS WITH AXIAL STRUT AND OTHER SYSTEMS. DIRECT IMAGING OF AXIAL STRUT AND SOLID REFLECTORS.
VERSACORP
JEFFREY R. CHARLES
12 JULY, 1997 REV. 13 July (Other Rev. as Noted)
DETAIL OF TORROIDAL ASPHERIC AXIAL STRUT REFLECTOR WITH MAXIMUM APERTURE OF ABOUT F/4 AND NO CENTRAL OBSCURATION OF SUBJECT.
CAN HAVE OVERLAP IN CENTRAL COVERAGE. PATENT PENDING.
AXIAL STRUT CAN BE SHORTER FOR ANGLES OF VIEW LESS THAN 320°.
SEC. OBS.
0°
90°
180°
270°
320°
ANGULAR COVERAGE
RELATIVE SIZE OF OBSTRUCTION CAN BE SMALLER IF LARGER REFLECTOR USED ON EITHER VERSION.
OPTICAL WINDOW (OR CORRECTOR OPTICS, IF NEEDED)
APERTURE
NOT NECESSARILY SHOWN TO SCALE OR IN OPTIMUM CONFIGURATION(S).
TORROIDAL REFLECTOR
TYPICALLY HAS RADIALLY OFFSET PROLATE ASPHERIC FIGURE. CAN BE PLASTIC OR METAL; ALUM, SILV, CHROME OR RHODIUM, ETC., CTD.
FILM OR SENSOR
T-THREAD OR OTHER INTERFACE
FIELD FLATTENER
320°
SECONDARY MIRROR CAN HAVE HOLE OR CLEAR AREA AT CENTER AND CONCENTRIC REFRACTING OPTIC CAN OCCUPY CENTER IN ORDER TO IMAGE CENTRAL PART OF SUBJECT ON SAME FILM OR SENSOR. SEPARATE CAMERA OR SENSOR CAN BE IN FRONT OF SECONDARY. EITHER CONCEPT WILL REQUIRE THE FRONT OPTICS TO HAVE A WIDER FIELD OF VIEW FOR CLOSER DISTANCES DUE TO PARALLAX. FIELDS OF VIEW CAN BE MATCHED WITH DIGITAL ZOOM AND/OR ZOOM OPTICS. STRUT CAN BE HOLLOW FOR WIRING. WIRING CAN (BUT DOES NOT HAVE TO) BE AXIAL TO OPTICAL CENTER OF LENS FOR "INVISIBLE" OFF-AXIS ROUTING.
POLAR ARRAY SENSOR CAN BE USED AND/OR ANNULAR IMAGE CAN BE RADIALLY COMPRESSED INTO CENTER AREA TO MAKE IMAGE AN UNOBSTRUCTED CIRCLE.
ANY COMBINATION OF FEATURES CAN BE INTERCHANGED BETWEEN ANY VERSION.
< HAS REAR CLEARANCE FOR SLR CAMERAS AND CONVENTIONAL VIDEO OR DIGITAL CAMERA MOUNTINGS AND SENSOR COVERS. SUPLEMENTARY PERISCOPIC OPTICS CAN IMAGE WHAT IS BEHIND CAMERA AND/OR REDUNDANTLY IMAGE CENTER OF SUBJECT ON SAME OR SEPARATE FILM OR SENSOR, ON AXIS OR OUTSIDE THE ANNULAR IMAGE. EITHER VERSION IS APPLICABLE TO PROJECTORS.
DETAIL OF RADIALLY OFFSET ASPHERIC AXIAL STRUT REFLECTOR WITH MAXIMUM APERTURE OF F/2 AND 20° CENTRAL OBSCURATION OF SUBJECT.
PATENT PENDING
SECONDARY REFLECTOR.
FLAT SHOWN. CAN BE CONVEX OR CONCAVE. IF LARGER AND SLIGHTLY CONCAVE, RELATIVE SIZE OF IMAGED OBSCURATION CAN BE SMALLER.
OPTIONAL LARGER STRUT NEAR TOP
SEC. OBS.
20°
90°
180°
270°
320°
ANGULAR COVERAGE
RADIALLY OFFSET ASPHERIC PRIMARY REFLECTOR FIGURE >
APERTURE
IMAGING OPTICS
OPTIONAL FIELD FLATTENER
FIELD FLATTENER
FILM OR SENSOR
320°
OTHER CONCEPTS:
* VR BOOTH, SUITE OR THEATER WALLS CAN BE (OR BE COVERED WITH) IMAGE DISPLAY DEVICES FOR BRIGHTER IMAGES THAN BY PROJECTION.
* SQUARE EXTRUSION (CUSTOM OR STD.) FOR DIAGUIDER. CUSTOM SHOWN BELOW:
OPTIONAL SHAPE (8 PLACES)
MULTI-FORMAT "L" BRACKET FOR VERTICAL POSITIONING OF CAMERA AND OPTICS. ALLOWS EYE CLEARANCE.
DIRECT IMAGING WITH AXIAL STRUT WIDE ANGLE REFLECTOR (U.S. PATENT D312,263)
AXIAL STRUT
FILM OR DIGITAL CAMERA (OR SENSOR WIRED TO CIRCUIT BEHIND REFLECTOR)
REFLECTOR. (VARIOUS SIZES AND FIGURES) LONGITUDINAL POSITIONING MEANS CAN BE INSIDE. FIGURE CAN BE INWARRDLY OFFSET (CENTER IS POINTED) TO INCREASE RADIAL IMAGE SCALE.
OPTICAL WINDOW (PLASTIC OR GLASS, ETC.) OR SPIDER CELL WITH OPTIONAL INTEGRAL OR SEPARATE CLOSE UP LENS.
CELL CAN BE EXTENDED TOWARD REFLECTOR IN ORDER TO SHORTEN STRUT, BUT THIS WILL CAUSE THE REFLECTION OF THE CELL TO APPEAR LARGER. AN EXTREME VERSION OF AN EXTENDED CELL WOULD BECOME SIMILAR TO FRENCH PATENT 1,234,341 BALTES 10/17/1960. CENTER AND OUTSIDE OF IMAGECAN BE DIGITALLY TRANSPOSED. IN PHOTOSHOP, THIS INVOLVES USING THE INVERSE POLAR COORDINATES FUNCTION, ROTATING THE IMAGE 180°, THEN USING POLAR COORDINATES FUNCTION. (OMNILENS CENTRAL OPTIC ANGLE CAN BE VARIABLE BY USING FRONT ELEMENT IN CONJUNCTION WITH CONCAVE FRONT CENTRAL TRANSPARENT SPOT (7-14). IN PREV. DWG.)
OMNILENS AND DIRECT IMAGING OF INTERNAL OMNI REFLECTOR SURFACE WITHIN SOLID ELLIPTICAL OPTIC.
SHOWN – MINIATURE VERSIONS WHICH ARE APPLICABLE TO ENDOSCOPY AND OTHER APPLICATIONS. CAN BE MADE ANY SIZE. VERSIONS OF SOLID REVERSE (RETRO) REFLECTOR WHICH ARE FOR USE OUTSIDE LIQUID OR FAST MOVING AIR (SUCH AS FOR GENERAL USE OR SPACE MISSIONS) NEED NOT HAVE THE FRONT SECTION, WHICH IS USED TO ASSIST WITH INSERTION. THESE OPTICS CAN BE INTEGRAL PARTS OF INSTRUMENTS OR BE SIMPLE PUSH ON, SCREW ON, ETC., PARTS. CAN BE MADE INEXPENSIVELY, PARTICULARLY IF MOLDED OF PLASTIC, MAKING THEM APPLICABLE EVEN TO DISPOSABLE APPLICATIONS. PATENT PENDING.
CAN HAVE OVERLAP
0°
360°
FRONT SECTION (NOT NEC. OPTICAL MAT'L) OPTIONAL COAX OPTICS.
SOLID OPTIC
INTERNAL REFLECTOR SURFACE.
OBJECTS DIRECTLY IN FRONT OF RETRO REFLECTOR SYSTEM APPEAR AROUND EDGE OF IMAGE. EITHER VERSION APPLICABLE TO SPACECRAFT.
OMNILENS (PARABOLIC, ELLIPTICAL, OR VAR. OUTLINES)
SOLID RETRO REFLECTOR. (SIMPLE) (IS LONGER IF IMMERSED 7-14)

INVENTIONS: FULLY REDUNDANT OMNIDIRECTIONAL IMAGING SYSTEM FOR SIMULTANEOUS CAPTURE OF STEREO OMNIDIRECTIONAL IMAGES. ALSO APPLICABLE TO 3D STEREO OMNIDIRECTIONAL PROJECTION OF VR IMAGES.

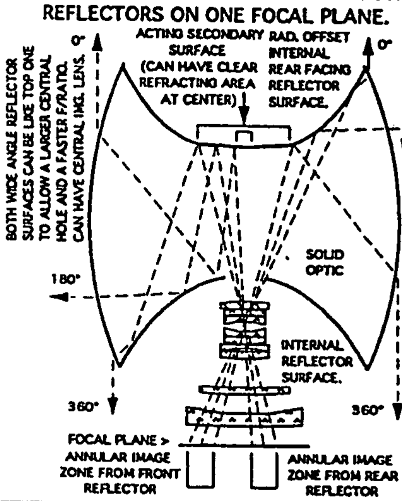
FOR SOLAR ECLIPSES, SIMULATIONS, MONITOR AND CONTROL OF OF FLIGHT AND OTHER SYSTEMS. (MANY EMBODIMENTS USE MY AXIAL STRUT REFLECTOR U.S. PATENT NO. D312,263) AND/OR MY SOLID CATADIOPTRIC WIDE ANGLE OPTICAL SYSTEM. (PATENT PENDING) (NOT NECESSARILY SHOWN TO SCALE)

ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC. AND TO PROJECTION OF PHOTOGRAPHIC, HOLOGRAPHIC, HYBRID, OR COMPLETELY COMPUTER GENERATED GRAPHICS.

VERSACORP
JEFFREY R. CHARLES
9 AUG, 1997 REVISED AS NOTED.

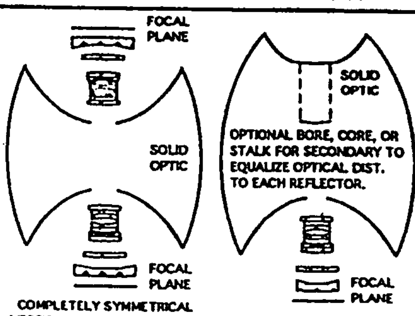
TOTAL VR (TM), TOTAL IMMERSION VR (TM), OMNIPROFLECTOR (TM), IMAGING AND PROJECTION SYSTEMS. IMAGES PRODUCED WITH THESE SYSTEMS AND WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS AND/OR COMPUTER GRAPHICS OR PROCESSING CAN BE PROJECTED WITH WHESE OPTICAL SYSTEMS. THESE SYSTEMS EVEN FACILITATE STEREO PROJECTION FROM SINGLE OR MULTIPLE FILMS, DISPLAY DEVICES, OR A COMBINATION THEREOF.

NEAR SYMMETRICAL SOLID ELLIPTICAL OPTIC WITH CONCENTRIC IMAGING FROM TWO REFLECTORS ON ONE FOCAL PLANE.




IF REQUIRED, OPTICS FOR BRINGING FRONT AND REAR REFLECTOR IMAGES TO A COMMON LONGITUDINAL FOCUS CAN BE BETWEEN REFLECTORS OR CLOSER TO THE FOCAL PLANE.

FRONT CONCAVE AREA CAN BE FILLED IN WITH VARIOUS MATERIALS WHERE NECESSARY FOR AERODYNAMIC CONSIDERATIONS, ETC. MULTIPLE SYSTEMS CAN BE USED FOR MORE REDUNDANCY. CAN BE USED HIGH ON AIRCRAFT TAIL OR AT OTHER LOCATIONS.




COMPLETELY SYMMETRICAL VERSION HAS SMALLER IMAGE FROM FORWARD FACING REFLECTOR. SHOWN WITH TWIN FOCAL PLANES.

VERSION WITH SMALLER REAR FACING REFLECTOR

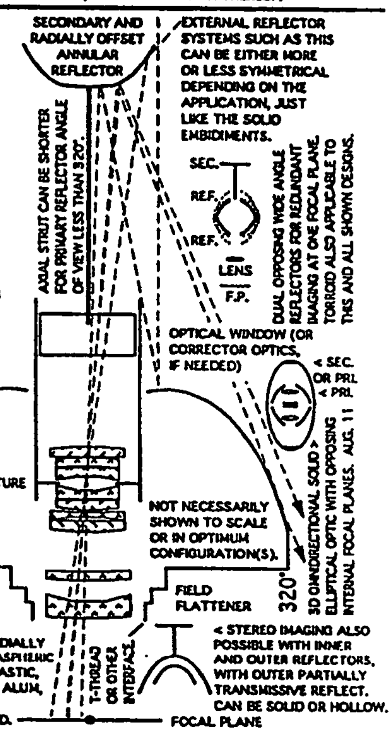
UNIT(S) CAN BE ROTATED OR PRECESSED ABOUT ANY AXIS/AXES IF AND AS REQUIRED FOR VARIOUS TASKS, EVEN AT HIGH SPEED. ALL WIDE ANGLE AND OTHER CONCEPTS SHOWN HERE AND IN OTHER DRAWINGS ARE ALSO APPLICABLE TO MINI ENDOSCOPES, OPTICAL AND OTHER COMMUNICATIONS, MOTION DETECTION, LASERS, ANTENNAS, (INCLUDING RADAR) SOUND MONITORS, RECORDERS (INCL. MICROPHONES) AND EMITTERS, PLUS FLUID SYSTEMS, ETC.

SYSTEMS CAN BE USED FOR IMAGING AND PROJECTION IN STEREO. IF USED SIDEWAYS, THE INVENTION WILL IMAGE WITH LATERAL STEREO SEPARATION. IF USED VERTICALLY, IT WILL HAVE VERTICAL STEREO SEPARATION. VERTICAL SEPARATION CAN BE DIGITALLY CONVERTED TO LATERAL SEPARATION FOR VR PROJECTION APPLICATIONS. PROCESSED OR UNPROCESSED IMAGES CAN BE PROJECTED BACK THROUGH THE SAME OR A SIMILAR OPTICAL SYSTEM. PROCESSING IS RECOMMENDED SINCE THE PROJECTION SURFACE MAY BE A DIFFERENT DISTANCE FROM THE OPTICS THAN THE ORIGINAL SUBJECT. STEREO EFFECT CAN BE DIGITALLY EXAGGERATED IF DESIRED. THE SOLID OPTIC ASSURES ALIGNMENT OF THE OPTICS AND RESULTING IMAGES. THE CONCEPT OF FACING OR OPPOSED REFLECTORS OR OTHER OPTICS IS ALSO APPLICABLE TO SYSTEMS UTILIZING TWO OR MORE IMAGE SENSORS OR FILM PLANES, ONE AT EACH END OF THE SYSTEM (OR BOTH IN THE CENTER WHERE APPLICABLE). THESE CONCEPTS CAN BE IMPLEMENTED AS A SYSTEM WHERE EACH SENSOR, ETC., IMAGES ONE REFLECTOR, OR, PARTICULARLY IN THE CASE OF A SYMMETRICAL OPTICAL SYSTEM, IT CAN BE IMPLEMENTED AS A SYSTEM IN WHICH BOTH REFLECTORS ARE IMAGED AT EACH IMAGE PLANE, RESULTING IN A TOTAL OF FOUR OMNIDIRECTIONAL IMAGES FROM A SINGLE OPTICAL SYSTEM! IDEAL FOR MISSILE SYSTEMS.

COMBINED SECONDARY REFLECTOR AND ANNULAR REAR FACING WIDE ANGLE REFLECTOR. IF THIS OPTIC IS MADE AS A SOLID REFLECTOR WITH AN INTERNAL REFLECTING SURFACE, THE ANNULAR REFLECTOR CAN COVER A GREATER ANGLE AND EVEN "SEE" THE CENTRAL SUBJECT AREA A MODEST DISTANCE BEHIND ITSELF. IF THE ENTIRE SYSTEM IS SOLID FROM THE OPTICAL WINDOW FORWARD, THE AXIAL STRUT CAN BE ELIMINATED. IF THE OPTICS ARE MADE OF MOLDED PLASTIC, IT IS POSSIBLE TO MAKE ALL OF THEM, INCLUDING THE PRIMARY REFLECTOR AND TRANSPARENT STRUT, FROM ONE OR TWO PARTS.

ALL DESIGNS APPLICABLE TO IMAGING AND PROJECTION, WITH PROJECTION CAN EITHER BE FROM A CENTRAL OR OFF-CENTER POSITION, DEPENDING ON THE FIGURE AND APPLICATION.

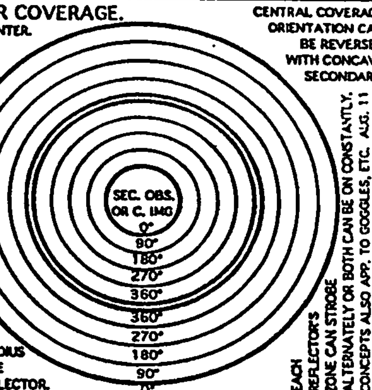
A SECOND PROJECTOR LENS CAN BE USED AS A CLOSE UP LENS TO ALLOW DIRECT PROJECTION ONTO THE REFLECTOR SYSTEM. LASER DIODE ARRAY CAN ALSO BE USED AS PROJECTION SOURCE. AUG. 11.




REDUNDANT ANGULAR COVERAGE.

REAR REFLECTOR FIELD NEAR CENTER. RELATIVE SIZE OF OBSTRUCTION CAN BE SMALLER AS SYSTEM IS MADE LARGER. SHOWN ANGLES OF VIEW ARE RELATIVE TO THE FOCAL PLANE, WITH 0° BEING DIRECTLY IN FRONT OF THE FOLAL PLANE AND 360° BEING DIRECTLY BEHIND IT. THE TWO BLACK LINES AT THE 360° ZONE REPRESENT A NARROW TRANSITION ZONE BETWEEN THE PRIMARY AND SECONDARY REFLECTORS WHICH WOULD BE VISIBLE IN CASES WHERE THE SECONDARY REFLECTOR RADIUS IS DIFFERENT FROM THAT OF THE SURROUNDING REAR FACING REFLECTOR.

CENTRAL COVERAGE ORIENTATION CAN BE REVERSED WITH CONCAVE SECONDARY.




IN SOME CASES, ONE OR MORE SPECIFIC OPTICAL SURFACES OR ELEMENTS MAY BE REQUIRED TO ACHIEVE A COMMON LONGITUDINAL FCUS FOR THE FRONT AND REAR REFLECTORS AT THE IMAGE PLANE. IMAGES FROM BOTH REFLECTORS CAN BE OVERLAPPED IF THE COATING OF ONE OR MORE IS PARTIALLY TRANSMISSIVE.

Invention(s): FULLY REDUNDANT OMNIDIRECTIONAL IMAGING WITH ONE OPTICAL SYSTEM.

This disclosure is considered as illustrative of the principles of the invention...

This disclosure and the principles

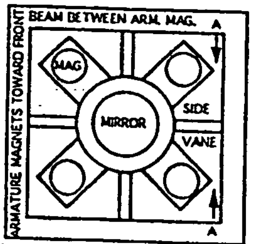
INVENTIONS:

* OMNIDIRECTIONAL ILLUMINATION MEANS FOR OMNILENS OR EXTERNAL REFL.
* EXCERPTS FROM PATENT AP. NO. 60/055,876 (TORROIDAL REFLECTOR).
* ABERRATION CORRECTION MEANS FOR WIDE ANGLE REFLECTOR.
* STEERING/STABILIZATION MIRROR WITH NO VELOCITY MAG. OR AXIAL FLEXURE.
* VERSAFOCUS (TM) FOCUSER WHICH MOVES LENS BUT NOT CAMERA.

ALL CONCEPTS, DESIGNS, AND METHODS APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC.

VERSACORP
JEFFREY R. CHARLES
8 DEC., 1997 REVISED AS NOTED.
TOTAL VR (TM) TOTAL IMMERSION VR (TM) TOTAL 3D (TM) VERSAVIEW (TM) VERSA VR (TM) OMNIRAMA (TM) OMNILENS (TM) IMAGING AND PROJECTION SYSTEMS. VERSAFOCUS (TM) FOCUSER.

STEERING AND IMAGE OR BEAM STABILIZATION REFLECTOR HAVING NO REQUIREMENT FOR VELOCITY MAGNETS (OR COILS) OR AN AXIAL FLEXURE. APPLICABLE TO MANY STEERING AND STABILIZATION MIRROR CONCEPTS, INCLUDING THE MINI LASER STEERING MIRROR I DEVELOPED AT JPL IN 1992 AND THE STEERING / INSTRUMENT SELECTION MIRROR I CONCEIVED FOR MY ALAT CONCEPT.




FRONT VIEW (SIMPLIFIED)

CURVED FLEXURE VANES CAN BE USED IN SHOWN DESIGN OR IN A UNIT HAVING A COPLANAR FLEXURE. CURVED VANES WARP IN ORDER TO "STRETCH" BETTER.


< TOP, BOTTOM VANES ANGLE TOWARD FRONT.

SIDE FLEXURE VANES ANGLE TOWARD BACK. ANGLED VANES PROVIDE AND/OR ENHANCE LONGITUDINAL STABILITY WITHOUT AN AXIAL FLEXURE

LASER OR OTHER SOURCE USED WITH QUAD SENSOR, HIGHER RES. CCD ARRAY, OR OTHER SENSOR TO PROVIDE POSITION INFO. BY SENSING REFLECTION FROM MOVING REFLECTOR.

SIDE VIEW (SIMPLIFIED CROSS-SECTION VIEW TAKEN ALONG LINE A-A)

APPLICABLE TO VERSIONS WITH 3 (OR OTHER NO. OF) MAGNETS AND VANES. OPTICAL VELOCITY/CALIBRATION CAN: BE COAXIAL WITH STEERED BEAM, "LOOK" STRAIGHT INTO REFLECTOR, UTILIZE THE CROSS AXIS, OR OTHER.

EXCERPTS FROM U.S. PATENT APPLICATION 60/055,876: WIDE ANGLE OPTICAL IMAGING AND PROJECTION SYSTEM HAVING 3D AND CENTRAL IMAGING MEANS...

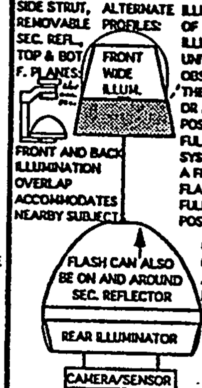
Sheet 14 shows torroidal and radially offset reflector systems with conceptual designs for specialized imaging lenses which have a fast f/ratio, field flattening means, and correction for astigmatism and other aberrations. It also shows other items. Top left figure is a side cross-sectional view of a torroidal reflector system having no central obscuration angle. A conceptual design for optics which include correction for aberrations and field curvature yet still provide adequate back focus for a standard single lens reflex camera. A circular diagram showing image distribution is also shown with this figure. Upper right figure is a side cross-sectional view of a radially offset wide angle reflector system having a 20 degree central obscuration angle and fast f/ratio optics. A circular diagram showing image distribution is also shown with this figure.

NEW COMMENTS NOT INCLUDED IN APPLICATION:

While spherical and conventional aspheric optics can be used to correct astigmatism (from reflector), chromatic aberrations (from solid OmniLens substrate or other source) and other aberrations, the use of hybrid aspheric elements is also applicable. Such an element (or elements, depending on how many required for a given system) can be entirely aspheric or can embody aspheric zones, reverse aspheric deviation from a sphere at zones near the center vs. those near the edge, other hybrid curves, or "annular" figures such as, but not limited to, figures used in a Schmidt corrector for a telescope or astrograph. Completely annular elements are also applicable, though there are some drawbacks to these. Corrections can also be partially or completely implemented at and with the secondary reflector, where a secondary reflector is part of a given system. All such designs can be implemented in various optical materials, but where thermal and other considerations permit, precision molded plastic optics are the most desirable due to their lower unit cost. In some cases, Fresnel lenses could be utilized at some or all zones.

OMNIDIRECTIONAL ILLUMINATION MEANS FOR OMNILENS OR EXTERNAL WIDE ANGLE OR OTHER REFLECTOR(S).

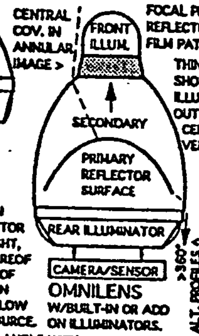
ILLUMINATION SYSTEMS CAN BE USED BOTH IN FRONT & IN BACK OF THE OPTICAL SYSTEMS. WHERE FLASH IS USED, THE FRONT ILLUMINATION UNIT CAN BE FIRED BY A PHOTOSENSITIVE SLAVE UNIT IN ORDER TO PREVENT THE NEED FOR WIRES WHICH COULD OBSTRUCT OR MAR THE IMAGE. WHERE WIRES ARE NECESSARY, THESE CAN BE RUN LOOSE, UP A SIDE STRUT, UP AN AXIAL STRUT, OR SIMPLY UP THE OPTICAL AXIS, WITH OFF-AXIS ROUTING BEING POSSIBLE (BEST) AT OR NEAR THE PLANE OF THE LENS IRIS, IF ANY. FULL SPHERE ILLUMINATION IS POSSIBLE BECAUSE ALL SHOWN SYSTEMS HAVE AN OBSCURED CENTRAL AREA TO ACCOMMODATE A FRONT LIGHT SOURCE OR ARRAY THEREOF. DISTRIBUTION OF A FLASH OF LIGHT (OR MULTIPLE STROBES FOR ACCUMULATED OR FULL MOTION IMAGES) THROUGH THE IMAGING SYSTEM IS ALSO POSSIBLE, AS DESCRIBED IN MY DOCUMENT OF NOV. 6, 1997.




AXIAL OR SIDE STRUT SYSTEM

IF CAMERA OR SENSOR IS IN FRONT OF PRIMARY REFLECTOR (ON ANY SYSTEM), ONE LIGHT, STROBE, OR OR ARRAY THEREOF CAN BE ON OPPOSITE SIDE OF CAMERA AS REFLECTOR. AN ADDITIONAL MASK CAN ALLOW USE OF A LARGER LIGHT SOURCE.

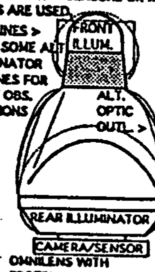
CENTRAL COV. IN ANNULAR IMAGE >




OMNILENS W/BUILT-IN OR ADD ON ILLUMINATORS.

FOCAL PLANE CAN BE INSIDE OF PRIMARY REFLECTOR ESPEC. IF SENSORS OR ROUTED FILM PATHS ARE USED.

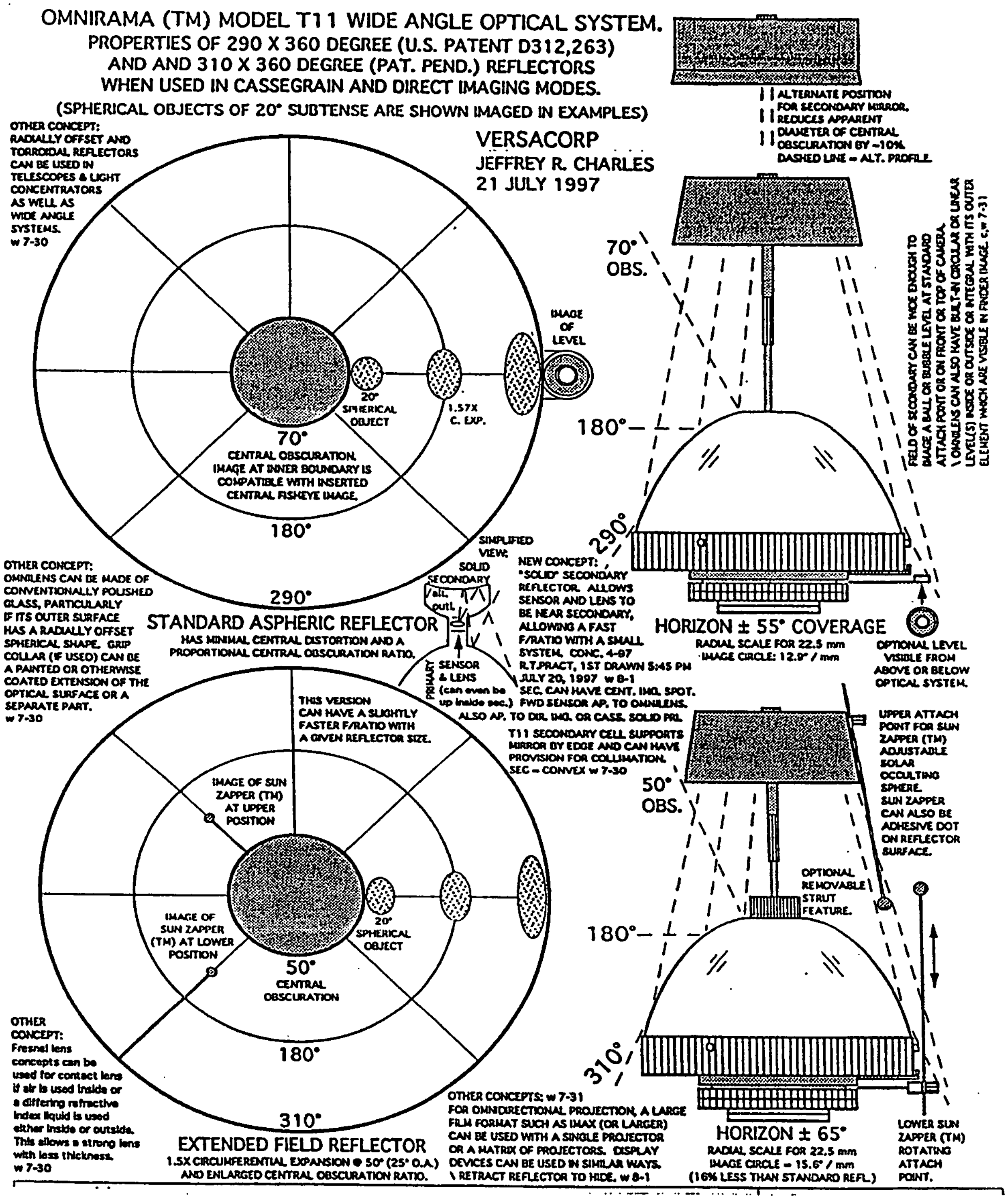
THIN LINES > SHOW SOME ALT ILLUMINATOR OUTLINES FOR CENT OBS. VERSIONS




OMNILENS WITH PROTRUDING SECONDARY (FROM 23 MAR. 1997 DWG.)

SOLID OPTIC COVERS MORE ANGLE WITH A SHALLOWER REFLECTOR FOR LESS ABERRATION. OUTSIDE SURFACE OF SOLID (OR GROUPED) OPTIC CAN ALSO INCLUDE CORRECTION MEANS. OPTIC, ILLUMINATOR, OR ACCESSORIES CAN INCLUDE MICROPHONE ARRAYS, ODOR SENSORS, ETC. AXIAL AND EXTERNAL STRUT VERSIONS CAN HAVE CABLING ROUTED ON OR IN STRUT. DATA, CONTROL, & EVEN SOME POWER CAN BE TRANSMITTED OPTICALLY OR BY INDUCTION. 2 MICRON OPTICAL OR OTHER COM. WAVELENGTH CAN UTILIZE THE IMAGING OPTICS. Dec. 9.

Invention(s): ILLUMINATION MEANS FOR OMNIDIRECTIONAL OPTICAL SYSTEMS. 2 focal planes w/annular sec. and | This disclosure and the principles


OMNIRAMA (TM) MODEL T11 WIDE ANGLE OPTICAL SYSTEM.
PROPERTIES OF 290 X 360 DEGREE (U.S. PATENT D312,263)
AND AND 310 X 360 DEGREE (PAT. PEND.) REFLECTORS
WHEN USED IN CASSEGRAIN AND DIRECT IMAGING MODES.
(SPHERICAL OBJECTS OF 20° SUBTENSE ARE SHOWN IMAGED IN EXAMPLES)
VERSACORP
JEFFREY R. CHARLES
21 JULY 1997
OTHER CONCEPT: RADIALLY OFFSET AND TORROIDAL REFLECTORS CAN BE USED IN TELESCOPES & LIGHT CONCENTRATORS AS WELL AS WIDE ANGLE SYSTEMS. w 7-30
ALTERNATE POSITION FOR SECONDARY MIRROR. REDUCES APPARENT DIAMETER OF CENTRAL OBSCURATION BY ~10%. DASHED LINE = ALT. PROFILE.
70° OBS.
IMAGE OF LEVEL
20° SPHERICAL OBJECT
1.57X C. EXP.
70°
CENTRAL OBSCURATION. IMAGE AT INNER BOUNDARY IS COMPATIBLE WITH INSERTED CENTRAL FISHEYE IMAGE.
180°
290°
180°
290°
FIELD OF SECONDARY CAN BE WIDE ENOUGH TO IMAGE A BALL OR BUBBLE LEVEL AT STANDARD ATTACH POINT OR ON FRONT OR TOP OF CAMERA. \ OMNILENS CAN ALSO HAVE BUILT-IN CIRCULAR OR LINEAR LEVEL(S) INSIDE OR OUTSIDE OR INTEGRAL WITH ITS OUTER ELEMENT WHICH ARE VISIBLE IN FINDER IMAGE. c. w 7-31
OTHER CONCEPT: OMNILENS CAN BE MADE OF CONVENTIONALLY POLISHED GLASS, PARTICULARLY IF ITS OUTER SURFACE HAS A RADIALLY OFFSET SPHERICAL SHAPE. GRIP COLLAR (IF USED) CAN BE A PAINTED OR OTHERWISE COATED EXTENSION OF THE OPTICAL SURFACE OR A SEPARATE PART. w 7-30
STANDARD ASPHERIC REFLECTOR
HAS MINIMAL CENTRAL DISTORTION AND A PROPORTIONAL CENTRAL OBSCURATION RATIO.
SIMPLIFIED VIEW: SOLID SECONDARY
alt. outl.
PRIMARY
SENSOR & LENS (can even be up inside sec.)
NEW CONCEPT: "SOLID" SECONDARY REFLECTOR. ALLOWS SENSOR AND LENS TO BE NEAR SECONDARY, ALLOWING A FAST F/RATIO WITH A SMALL SYSTEM. CONC. 4-97 R.T.PRACT, 1ST DRAWN 5:45 PM JULY 20, 1997 w 8-1 SEC. CAN HAVE CENT. IMG. SPOT. FWD SENSOR AP. TO OMNILENS. ALSO AP. TO DIR. IMG. OR CASS. SOLID PRI.
HORIZON ± 55° COVERAGE
RADIAL SCALE FOR 22.5 mm IMAGE CIRCLE: 12.9° / mm
OPTIONAL LEVEL VISIBLE FROM ABOVE OR BELOW OPTICAL SYSTEM.
THIS VERSION CAN HAVE A SLIGHTLY FASTER F/RATIO WITH A GIVEN REFLECTOR SIZE.
T11 SECONDARY CELL SUPPORTS MIRROR BY EDGE AND CAN HAVE PROVISION FOR COLLIMATION. SEC = CONVEX w 7-30
UPPER ATTACH POINT FOR SUN ZAPPER (TM) ADJUSTABLE SOLAR OCCULTING SPHERE. SUN ZAPPER CAN ALSO BE ADHESIVE DOT ON REFLECTOR SURFACE.
50° OBS.
IMAGE OF SUN ZAPPER (TM) AT UPPER POSITION
IMAGE OF SUN ZAPPER (TM) AT LOWER POSITION
20° SPHERICAL OBJECT
50°
CENTRAL OBSCURATION
180°
310°
OPTIONAL REMOVABLE STRUT FEATURE.
180°
310°
OTHER CONCEPT: Fresnel lens concepts can be used for contact lens if air is used inside or a differing refractive index liquid is used either inside or outside. This allows a strong lens with less thickness. w 7-30
EXTENDED FIELD REFLECTOR
1.5X CIRCUMFERENTIAL EXPANSION @ 50° (25° O.A.) AND ENLARGED CENTRAL OBSCURATION RATIO.
OTHER CONCEPTS: w 7-31 FOR OMNIDIRECTIONAL PROJECTION, A LARGE FILM FORMAT SUCH AS IMAX (OR LARGER) CAN BE USED WITH A SINGLE PROJECTOR OR A MATRIX OF PROJECTORS. DISPLAY DEVICES CAN BE USED IN SIMILAR WAYS. \ RETRACT REFLECTOR TO HIDE. w 8-1
HORIZON ± 65°
RADIAL SCALE FOR 22.5 mm IMAGE CIRCLE = 15.6° / mm (16% LESS THAN STANDARD REFL.)
LOWER SUN ZAPPER (TM) ROTATING ATTACH POINT.

# INVENTIONS: PANORAMIC AND OMNIRAMIC PRESENTATION.

## Preferred Single and Dual Projector Embodiments.

FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS. (MANY EMBODIMENTS USE MY AXIAL STRUT REFLECTOR INVENTION: U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)

ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC.

VERSACORP
JEFFREY R. CHARLES

8 AUG, 1997 LATE A.M. REVISED AS NOTED.

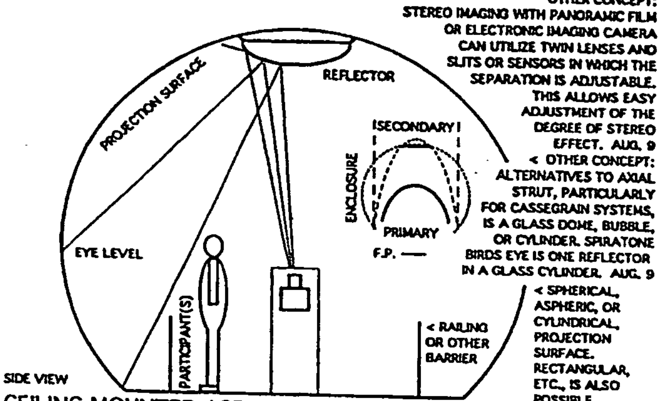
TOTAL VR (TM), TOTAL IMMERSION VR (TM) OMNIFLECTOR (TM), OMNIJECTOR (TM), OMNIPROJECTOR (TM) PROJECTION SYSTEMS FOR IMAGES MADE WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS.

OTHER CONCEPTS:

* Use of conventional Barlow lens like that for astronomical telescope as a field flattener for omnidirectional (particularly reflective) optical systems.
* Axial strut and secondary (or camera) with baffle retract inside unit to protect primary. Retracted secondary baffle can be made so it will completely cover the primary. Aug. 10.
* Two tandem reflectors (particularly in a solid optic) can provide fully redundant omnidirectional coverage for stereo imaging, ranging, projection, etc. All des. can utilize conv., torroidal, etc., refl. See top corner figures below. Aug. 10.

## TOTAL VR (TM) TOTAL IMMERSION VR (TM) OMNIDIRECTIONAL PROJECTION SIMULATORS, GAMES, BOOTHS, SUITES, THEATERS:

PROJECTION ORIGINAL CAN BE A FILM OR ELECTRONICALLY PRODUCED IMAGE. SUBJECT CAN BE REAL, HYBRID, OR ENTIRELY COMPUTER GENERATED. COMPUTER GENERATED SOURCE IMAGE(S) MORE EASILY ALLOW THE SURROUNDINGS TO CHANGE ACCORDING TO PARTICIPANT'S ACTIONS, SINCE A LARGE NUMBER OF POSSIBILITIES CAN BE PROGRAMMED. THIS IS DESIRABLE FOR VIRTUAL REALITY SIMULATIONS, GAMES, ETC., INCLUDING "FULL CANOPY" FLIGHT SIMULATION. THESE CONCEPTS CAN ALSO BE USED TO PROJECT ON THE WALL BELOW A CONVENTIONAL PLANETARIUM DOME, ETC.




## CEILING MOUNTED ASPHERIC REFLECTOR CONCEPT.

### APPLICABLE TO SINGLE AND MULTIPLE MIRROR SYSTEMS.

SYSTEMS CAN BE USED AT ANY ORIENTATION, INCLUDING UPSIDE DOWN FROM THAT SHOWN. THESE WIDE ANGLE REFLECTOR SYSTEMS CAN BE INTEGRATED INTO A CUSTOM PROJECTOR ASSEMBLY OR THEY CAN BE FIXTURES THAT ARE USED WITH EXISTING PROJECTORS INCLUDING FILM PROJECTORS AND ELECTRONIC MEDIA PROJECTORS SUCH AS THE SINGLE LENS BARCO (R) COLOR LCD PROJECTOR. MULTIPLE LENS PROJECTORS CAN BE USED IF THE IMAGES ARE EITHER COMBINED BEFORE REACHING THE PRIMARY REFLECTOR OR IF THEY ARE BROUGHT TO A COMMON FOCUS AND CONVERGENCE AT THE VIRTUAL IMAGE "SURFACE" OF THE OPTICAL SYSTEM. WHERE APPROPRIATE, THE REFLECTOR(S) CAN BE CENTRALLY OR OTHERWISE MASKED.

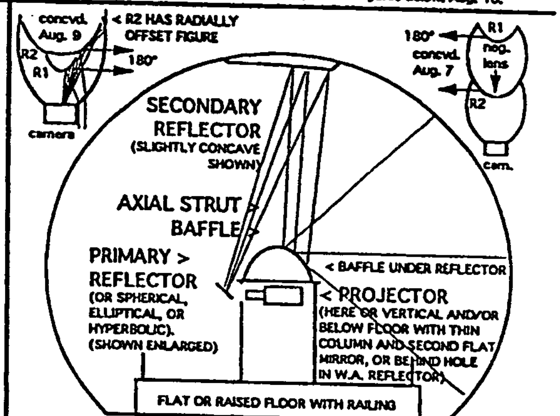
IF THE CEILING MOUNTED REFLECTOR IS A PRIMARY REFLECTOR USED WITH A FLOOR MOUNTED PROJECTOR, IT WILL TYPICALLY BE A CONVEX OBLATE ELLIPSOID. AN APPROPRIATE RADIALLY OFFSET REFLECTOR FIGURE (HAVING AN INWARD OFFSET WHICH RESULTS IN A POINTED CENTER) CAN BE USED TO ALLOW THE USE OF AN ORIGINAL PROJECTED IMAGE WHICH HAS LITTLE OR NO BLANK AREA IN THE CENTER, RESULTING IN A LARGER RADIAL IMAGE SCALE. THIS CENTRAL AREA WOULD BE EQUIVALENT TO THE PART OF THE FLOOR COVERED BY A CONVENTIONAL REFLECTOR THAT WOULD BE SUBJECT TO SHADOWING BY THE PARTICIPANTS. THE ORIGINAL PROJECTED IMAGE WILL HAVE THE GROUND (OR "DOWN") AT THE CENTER OF THE IMAGE AND THE SKY AROUND THE OUTSIDE. (BUT AN APPROPRIATE CONCAVE TORROID REFLECTOR CAN REVERSE THE SKY-GROUND RELATIONSHIP, ALLOWING THE ORIGINAL IMAGE TO HAVE THE SKY IN THE CENTER).

WHERE THERE ARE TWO (OR MORE) CEILING MOUNTED MIRRORS (I.E. A CASSEGRAIN SYSTEM, WITH EITHER THE SMALL OR THE LARGE MIRROR SERVING AS THE PRIMARY) ARE USED WITH A FLOOR MOUNTED PROJECTOR, THE ORIGINAL IMAGE CAN HAVE THE SKY IN THE CENTER, ALLOWING OTHER CHARACTERISTICS OF THE SYSTEM TO BE LIKE OR SIMILAR THOSE SHOWN AND DESCRIBED IN MY "OFF-CENTER ASPHERIC REFLECTOR" CONCEPT ON MY 30 MAY, 1997 DOCUMENT. ONE OR MORE OF THE REFLECTORS CAN CAN BE SUPPORTED BY AN AXIAL STRUT OR OTHER MEANS.

BUT AND PRIMARY REFLECTOR, THE PROJECTOR CAN EITHER BE BEHIND (UNDER) THE PRIMARY REFLECTOR AND PROJECT THROUGH A HOLE IN ITS CENTER OR IT CAN BE OFF-AXIS (PREFERRABLY AS CLOSE TO THE PRIMARY REFLECTOR OPTICAL AXIS AS POSSIBLE) AND PROJECT THE IMAGE TOWARD THE SECONDARY REFLECTOR FROM BESIDE THE PRIMARY. THIS OFF-AXIS PROJECTOR SYSTEM WILL ALSO ALLOW THE PROJECTOR TO BE POSITIONED HORIZONTALLY BEHIND THE PRIMARY REFLECTOR AND PROJECT THE IMAGE INTO A MIRROR IMMEDIATELY BESIDE THE PRIMARY WHICH IN TURN DIRECTS THE PROJECTION TOWARD THE SECONDARY REFLECTOR.

THE SECONDARY REFLECTOR CAN BE FLAT, CONVEX, OR CONCAVE, WITH A SLIGHTLY CONCAVE ONE FACILITATING THE USE OF A PROJECTOR LENS HAVING RELATIVELY CONVENTIONAL ANGLE OF VIEW.

A CEILING MOUNTED PROJECTOR AND MASKED OR UNMASKED 180 DEGREE FISHEYE LENS (POSSIBLY EVEN AN EXISTING ONE) CAN ALSO BE USED.

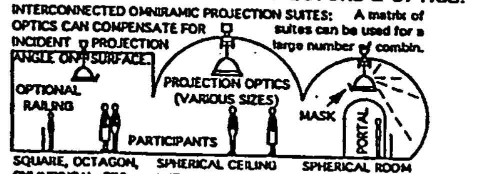



## FLOOR MOUNTED PROJECTOR AND OMNIRAMIC PRIMARY PROJECTION REFLECTOR FOR USE WITH CEILING MOUNTED SECONDARY.

SEPARATED OR MERGED OPTICAL CLUSTERS CAN BE USED FOR 3D IMAGING AND PROJECTION WITH OPTICAL STEREO SEPATATION PERPENDICULAR TO THE OPTICAL AXIS. > MERGED FOUR REFLECTOR CLUSTER SHOWN. C&D AUG. 11.

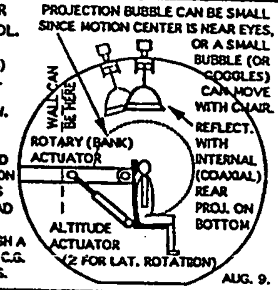
## ANY COMBINATION OF ROOM SHAPES CAN BE USED WITH ANY COMBINATION OF PROJECTORS & OPTICS:

INTERCONNECTED OMNIRAMIC PROJECTION SUITES: A matrix of suites can be used for a large number of combin.




### FLIGHT OR PROCESS SIMULATOR AND/OR MONITOR AND CONTROL.

PILOT(S) OR CONTROLLER(S) CAN STAND OR BE SEATED WITH HEAD(S) NEAR CENTER OF PROJECTION AREA. CAN HAVE FULL COCKPIT/CONTROL AREA VIEW OR FULL "CANOPY" VIEW. IDEAL FOR ROBOTICS OR UAVs. PROJECTOR CAN BE AT TOP WHERE SHOWN OR UP TO ABOUT 30° BEHIND HEAD OF PILOT/CONTROLLER. MOTION CONTROL (WHERE NEEDED) EFFECTS MOTION ABOUT AXES NEAR THE HEAD OF THE PILOT/CONTROLLER FOR A MORE REALISTIC EXPERIENCE, THOUGH A PIVOT POINT BELOW SEAT OR NEAR C.G. MAY WORK FOR SOME APPLICATIONS.




AUG. 9.